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# THE SURGICAL CLINICS of NORTH AMERICA

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NEW YORK NUMBER

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## *SYMPOSIUM ON BLOOD VESSEL SURGERY*

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### PORTACAVAL ANASTOMOSIS—OBSERVATIONS ON TECHNIC AND POSTOPERATIVE CARE

ARTHUR H. BLAKEMORE, M.D.\*

#### COMMON CAUSES OF PORTAL HYPERTENSION

CLINICIANS familiar with the natural history of Laennec's cirrhosis of the liver are well aware of the role of portal hypertension in that disease.

Ratnoff and Pitek<sup>1</sup> in an analysis of 386 cases of portal cirrhosis of the liver noted rupture of esophageal varices as the cause of death in 26 per cent of the cases.

Cirrhosis of the liver secondary to hepatitis is a not uncommon cause of portal hypertension and bleeding from esophageal varices.

Banti's syndrome with esophageal varices secondary to portal hypertension invariably leads to death sooner or later from hemorrhage.

Schistosomiasis of the liver that has developed to the point of causing esophageal varices as the result of portal obstruction almost invariably causes death eventually from hematemesis. And, finally, in two cases of our series repeated hematemesis resulted from portal vein obstruction secondary to pancreatitis.

#### RATIONALE OF THE PORTACAVAL SHUNT FOR THE CONTROL OF GASTROINTESTINAL HEMORRHAGE DUE TO PORTAL HYPERTENSION

When one considers in the above array of diseases that portal hypertension is one common factor responsible for dire consequences it

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coccus can wreck by thrombosis an otherwise perfect anastomosis should be a caution to all

Fortunately for us, some years before, necessity had forced the evolution of successful methods of dealing with this and other organisms. The occasion was the introduction of a method of wiring and electrothermic coagulation of aneurysms at the Presbyterian Hospital in 1935. This operation is a long procedure (as is the case with the portacaval shunt) and the opportunities for bacterial contamination are many. But more important, in the case of wired aneurysm was the early realization that minimal contamination with even the lowly *Streptococcus viridans* meant certain death for the patient.

The body seems incapable of offering defense against the combination of bacteria and wire when embedded in the clot of an aneurysm. Furthermore, under similar circumstances, experience has taught us that the use of modern antibiotics though cultures even prove the organism to be sensitive, is of little avail in saving the patient's life.

In the course of a year following the introduction of the electrothermic method for the treatment of aneurysms at the Presbyterian

scrub followed by alcohol ether, iodine and alcohol (3) Meticulous covering of the skin edge as follows: make the skin incision, ligate superficial blood vessels with fine silk, cover the skin edge with towels held in place by closely spaced Michel clips reinforced with a towel slip at either end of the wound. Discard all used instruments and change the gloves before proceeding with the operation. (4) The prevention of airborne infection by a bacteriologically controlled system of ultraviolet lights. (5) A pleasant but not essential addition to the foregoing regimen for the operating room is air conditioning.

Before the institution of this outlined regimen for the prevention of infection a total of five patients with wired aneurysm became infected, all of whom succumbed. After the institution of the combined regimen some 300 wiring operations for aneurysm were performed at the Presbyterian Hospital over a ten year period without a single infection. Recent experience has shown that penicillin even in large doses, cannot be depended upon to prevent infection in cases of aneurysm undergoing the wiring operation. In two cases in which penicillin was given in 100,000 unit doses before wiring and for fourteen days after operation at three hour intervals infection developed in the aneurysm in each case. A *Streptococcus viridans* organism was recovered from both. The only other variation of routine in these two operations was the omission of ultraviolet radiation. The above citation is made not to discourage the use of penicillin, but to illustrate that there are

is not surprising that the subject has received considerable thought in the past. In fact, ever since Von Eck in 1877 anastomosed the portal vein to the vena cava in dogs, surgeons have accepted the rationale of portacaval shunt for the amelioration of portal hypertension. Though the rationale of the procedure was early accepted, many years were required to forge those advances in surgery so essential to its clinical success.

- ✓ A method of establishing portacaval shunts to be clinically acceptable must meet two important requirements, namely (1) a high chance of survival for the patient, (2) a high likelihood of maintained patency of the anastomosis.

When, four years ago, Dr. Allen Whipple and I undertook our first splenorenal anastomosis in a 5 year old child having hematemesis from cirrhosis of the liver, we had no illusions about the difficulties in achieving the above requirements. After operation the child had a stormy time for a few days but recovered. One year later, encouraged by the remarkable clinical improvement in the first case, the operation was performed upon several additional patients without mishap. Encouraged by these early results our series was cautiously expanded *pari passu* with our gain in knowledge and experience. To date portacaval anastomoses have been accomplished forty times with a postoperative mortality of 12 per cent.

#### FACTORS INFLUENCING OPERATIVE RISK AND SUCCESS OF THE PORTACAVAL SHUNT PROCEDURE

Early in our experience we appreciated that success would depend primarily upon the selection of cases for operation, careful attention to technical details and preoperative and postoperative handling.

Our most serious handicap in the beginning was inadequate knowledge upon which to base an intelligent evaluation of the relative operative risk in a given case. This was particularly true when dealing with cases of cirrhosis of the liver and accounted for two of our postoperative deaths. In retrospect, we consider it most fortunate that we advanced our series cautiously in the beginning. This afforded an opportunity to study and observe individual cases over protracted periods. The information derived from these observations was of great importance in the formulation of our knowledge pertaining to the selection of cases for operation.

Previous experience in blood vessel surgery including the anastomosis of veins had prepared us to expect failure in maintaining permanent patency of portacaval shunts unless meticulous precautions were taken.

**Infection.**—The onus of infection must always be kept foremost in mind. The subtlety with which a so-called low grade green strepto-

hypertension that the blood pressure and rate of blood flow through the portacaval shunts are adequate for the continued maintenance of the anastomoses

Conceding the above facts does not argue that portacaval shunts enjoy the same margin of hemodynamic favor as do arterial anastomoses where the blood pressure is several times higher. On the contrary, recognition of the basic fact that the margin of hemodynamic favor is narrow in portacaval anastomosis necessitates the employment of measures to insure success that would not ordinarily be considered essential in arterial anastomosis. These measures may be listed as follows:

1 *The avoidance of twisting of the anastomosed veins*, or angulation upon repositioning of the viscera

2 *Measures to maintain the blood pressure at satisfactory levels* from the time the anastomosis is opened until it is healed. Proper preoperative preparation of the patient, a good anesthesia (preferably cyclopropane), careful hemostasis, and the generous use of blood and blood substitutes are essential.

3 *Measures to prevent abdominal distention*. Prostigmine and rectal tube are given at four hour intervals, to be repeated for three or four days postoperatively. A nasogastric tube with suction or, if necessary, a Miller-Abbott tube and colon lavages when necessary are used. It must be remembered at all times that the pressure relations are such that abdominal distention may close off entirely for a time or greatly reduce the blood flow through a portacaval shunt, particularly a splenorenal anastomosis.

4 *Avoidance of early ambulation*. There can be considerable shift of the viscera between the horizontal and vertical positions. We believe it may take five or more days to rigidify tissues about an anastomosis sufficiently to prevent possible drag from a shifting organ in the neighborhood.

5 *Anticoagulant therapy*. Early in our experience we appreciated that many factors have a bearing on the successful outcome of the portacaval shunt. Some of these factors we can absolutely control and some we can influence only in part. Anticoagulant therapy postoperatively, however distasteful the idea, seemed a possible solution to the problem. For example, we have already spoken of the importance of adequate blood pressure upon the maintenance of patency in the portacaval shunt and of the narrow margin that portal hypertension affords in its behalf. We have alluded to the many opportunities of fluctuation in blood pressure in spite of rigid controls. To this add our observation that during the first twelve to twenty four hours postoperatively in many cases of portacaval shunt the patient becomes 30 to 50 per cent heparin fast. This means that the coagulability of the blood rises sharply over this period. This poses the problem of

bacteria resistant to its action and the failure to use ultraviolet radiation in these two cases has the appearance of a serious omission which we shall not repeat in the future.

When we undertook the investigation of the portacaval shunt knowing the subtle and vicious role of infection in venous anastomosis it was comforting to know that we could employ a technic of proven worth against infection. The technic as outlined including the use of penicillin is routine with us for the portacaval shunt procedure.

**Suture versus Nonsuture Method**—In our first portacaval shunt operation (a splenorenal anastomosis) and in most of our earlier operations we employed vitallium tubes using the nonsuture method. This method had proved highly successful in our hands in the anastomosis of arteries. While we did not know its relative efficiency in comparison with the suture method for the anastomosis of veins it did have the advantage of relative quickness of accomplishment. The latter seemed highly important to us in the beginning.

Early recognizing the importance of ascertaining the relative efficiency of the two methods of anastomosis we started a series of cases employing the suture method for the establishment of portacaval shunts. While there is not yet conclusive proof that the suture method is superior the score in three proven cases is nonsuture anastomosis closed two suture anastomosis closed one. All were splenorenal anastomoses. On the basis of this trend we have for some time been employing the suture method exclusively. The latter method does have the added advantage of conserving the kidney in the splenorenal type of portacaval shunt.

**Factors Stemming from Hemodynamics of Venous System**—Irrespective of the method employed and granting the observance of rigid blood vessel technic throughout there are yet other factors which I wish to discuss which have an important bearing upon the continued patency of portacaval shunts. All these factors stem basically from the hemodynamics of the venous system which in general when compared to the arterial system are unfavorable for the continued patency of anastomoses. However the portacaval shunt in particular when done in the presence of portal hypertension has a decided hemodynamic advantage over venous anastomoses elsewhere. The extreme importance of this increase in portal blood pressure as it affects the nature of portacaval shunts is best illustrated by the fact that ligation of the portal vein to vena cava

these anastomoses invariably close off usually within 100 to 200 days unless the portal vein is ligated between the anastomosis and the liver. The rise in portal blood pressure the result of ligating the portal vein and thus forcing all the blood through the anastomosis makes the difference between success and failure. We have demonstrated repeatedly in cases of portal

given case through a transverse abdominal incision any type of portacaval shunt may be accomplished

Current studies are in progress that may throw some light upon the relative efficiency and virtues of the two above-mentioned types of portacaval shunts

In cases of Bant's syndrome in which portal hypertension is the result of atresia of the portal vein in the portal fissure or due to cavernomatous transformation of the portal vein the latter is so encompassed by veins that it is out of the question to attempt an anastomosis of the portal vein to the vena cava. We now have a fair number of this group who previously have had their spleens removed and continued to bleed in which we have been able to establish the following types of portacaval shunt (1) anastomosis of the stump of the splenic vein to the vena cava end to side (2) anastomosis of the proximal end of the inferior mesenteric vein to the left renal vein end to side (3) anastomosis of the proximal end of the inferior mesenteric to the vena cava end to side (4) anastomosis of the superior mesenteric vein to the vena cava side to side. The results in this group have been most gratifying

#### TECHNICAL CONSIDERATIONS

Early in our studies when we employed the nonsuture technic using vitallium tubes to perform portacaval anastomoses we published a description of the technic.<sup>2</sup> Since shifting largely to the suture technic for the performance of portacaval shunts (embracing over half of our series) certain points in technic have been evolved which we think worth discussing

satisfactory for the control of bleeding at the anastomosis site in portacaval shunts

**Clamps**—A satisfactory suture anastomosis of the splenic vein to the renal vein can be carried out employing rubber-covered serafine (bulldog) clamps. Blood flow through the kidney is interrupted during the period of carrying out the anastomosis and it is important to remember that the kidney tolerates this state best when the renal artery also is occluded preferably before the vein.

In the portal vein to vena cava type of portacaval shunt whereas the serafine clamp is satisfactory for controlling blood flow through the portal vein during the period of the anastomosis it is highly undesirable to interrupt completely the blood flow through the vena cava. To do so would obstruct greatly venous return blood flow from both kidneys.



protecting the anastomosis against the combined threat of a falling blood pressure and a rising coagulability of the blood.

The presence of degenerative changes in the anastomosed veins is conducive to clotting. Particularly is this encountered in the spleno-renal type of portacaval shunt in which frequently the splenic vein is noted to have areas of dilatation in which the vein wall is extremely thin. Or there may be areas of sclerosis of the intima present. In several cases we have noted the intima reduplicated in folds. All these changes can, under certain circumstances, predispose to thrombosis. Finally, there is the thrombosis hazard of the nearly perfect anastomosis (perfection, with all its implications, is actually rarely attained).

The rational solution to the thrombosis problem is to control blood clotting from the time the portacaval anastomosis is opened until complete endothelialization of the anastomosis site takes place—a matter of four or five days. This normally carries the patient beyond the period of blood pressure fluctuations and abdominal distention.

We have been able to attain the above ideal in a fair number of selected cases. It is my belief that, in cases in which accurate hemostasis can be carried out at the operating table, elevation of the clotting time to twenty minutes postoperatively does not incur risk of serious hemorrhage. On the other hand, in my opinion, the maintenance of the clotting time at the first few days is the first prerequisite to safe heparinization in these cases.

### CHOICE OF OPERATION

In the majority of the forty cases in which portacaval shunts were performed, the end-to-side type of portacaval shunt was employed. The best abdominal

mended particularly in patients having extremely thick abdomens.

In six of the forty cases having a portacaval shunt procedure the portal vein to vena cava (end to-side) type of portacaval shunt was carried out. An upper abdominal transverse incision was employed in most of this group.

liver down against the handle of the clamp and thus pushing it off the vena cava

Figure 89 is a photograph of a rubber protected clamp which we have employed with satisfaction in the following types of portacaval shunt (1) end to side suture of the portal vein to vena cava (2) side to side anastomosis of the superior mesenteric vein to the vena cava (3) end to side suture of the inferior mesenteric vein to the vena cava (4) end to side suture of the splenic vein to the left renal vein

It should be noted that the clamp is compact. The jaws of the clamp can be firmly and evenly adjusted to the vein wall by means of a screw clevis located at either end. The clamp can be quickly demounted and removed at the conclusion of the anastomosis.

The above described clamp saves time in doing the splenorenal type of portacaval anastomosis because it makes it unnecessary to ligate and cut large vein branches (adrenal and ovarian or spermatic) joining the left renal vein from the sides. There are occasional cases in which the left renal vein is sufficiently large to permit some return venous flow from the kidney during the period of the anastomosis. However we also use an adjustable screw clamp (small Crile) for compression of the renal artery and in such cases adjust the arterial inflow to the point that there is no congestive cyanosis of the kidney.

**Resection of Tail of Pancreas**—In doing the splenorenal type of portacaval shunt we frequently resect some 2 or 3 cm. of the tail of the pancreas. The purpose of this is to prevent compression of the splenic vein by the tip of the pancreas as it curves downward to meet the left renal vein. In addition it permits full view of the splenic vein and the anastomosis upon repositioning the kidney. This enables the surgeon to make a final check regarding angulation or twisting of the anastomosed veins.

**Suture Technic**—If the renal vein is considerably larger than the splenic vein a transverse incision corresponding to the diameter of the splenic vein is made across the anterior surface middle one third of the left renal vein. In cases having smaller renal veins the incision is obliquely placed. The oblique or better transverse disposition of the incision causes the anastomosis when completed to assume an oval or round configuration. This is due essentially to the anatomical disposition of the muscle fibers in the vein wall.

Before starting the anastomosis perfect hemostasis should be attained. The lights should be adjusted for good vision. Loose areolar tissue adherent to the adventitia of the veins near the site chosen for anastomosis should be carefully removed. Fibrin particles adherent to the intima as well as blood clot should be thoroughly removed with normal saline-heparin solution.

New braided 5-0 silk well lubricated with petrolatum and threaded

Figure 88 is a photograph of a clamp especially designed to control blood flow at the site of the anastomosis on the vena cava, at the same



Fig. 88—An inadequate clamp for portacaval anastomosis (See text)

Whereas this handle makes for convenience in application of the clamp to the vena cava, I wish to call attention to two objections one of which is serious to this clamp or any other similarly designed clamp with a handle, namely (1) the forceps principle in a lightly constructed clamp is not conducive to equally distributed pressure



Fig. 89—A satisfactory clamp for portacaval anastomosis (See text)

upon the vein wall within its grasp, (2) the protruding handle of the clamp makes it an easy target for accidental avulsion of the clamp from the vessel within its grasp. Accidental avulsion of a clamp during an anastomosis could be calamitous, as it nearly was with us on one occasion when the patient suddenly coughed, forcing the enlarged

liver down against the handle of the clamp and thus pushing it off the vena cava

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New braided 5-0 silk well lubricated with petrolatum and threaded

on small curved needles is employed I find it easier to put in the back suture line first Starting at the far point a suture is taken

stitch is from within outward on the splenic vein followed by a mattress suture from without inward thence back and forth in identical manner from the splenic to renal veins until some four or five everting running mattress sutures are placed At this point both ends of the running mattress sutures are gently drawn taut approximating in everted fashion the cut edges of the splenic and renal veins Following this a stay suture is placed at either end and the running suture is tied at either end to their respective stay sutures Another series of four or five everting running mattress sutures is placed and again tied to stay sutures thus continuing until the posterior suture line is completed It is our practice to complete the anterior suture line also with a running everting mattress suture frequently interrupted by stay sutures The anastomosis is frequently

the intima  
possible to  
after the

anastomosis is open

Upon completing the anastomosis the rubber covered clamp on the splenic vein is opened followed immediately by removal of the proximal occluding clamp on the renal vein A slight leak at any point in the anastomosis may be controlled by gentle sponge compress on for a few moments If the anastomosis appears tight the rubber covered clamp on the renal vein and artery is released

A great deal of unnecessary confusion and blood loss may be eliminated at the time of opening the anastomosis if the surgeon has properly and carefully ligated with transfixion ligatures all venous branches in mobilizing the splenic vein before starting the anastomosis Usually a 4 to 5 cm segment of splenic vein is adequate Extreme

in its normal position posteriorly

#### SUMMARY

Some of the common causes of portal hypertension are reviewed The rationale of the portacaval shunt for the control of gastrointestinal hemorrhage due to portal hypertension is discussed

Factors having a bearing upon the operative risk and success of the portacaval shunt procedure are emphasized

Points in technic are discussed

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## THE SURGICAL TREATMENT OF ESSENTIAL HYPERTENSION

### A Comparison of the Results of the Classical Smithwick Operation and the Extensive Thoracolumbar Sympathectomy

J WILLIAM HINTON, M D, F A C S \* AND  
JERE W LORD JR, M D, F A C S †

IN a paper describing a modification of Smithwick's<sup>1</sup> classical thoracolumbar sympathectomy for hypertension the authors<sup>2</sup> illustrated and discussed a technic which made possible the removal of the sympathetic chain from the third or fourth thoracic ganglion through the second or third lumbar ganglion. It was stated<sup>2</sup> that "the rationale for increasing the extensiveness of the procedure is based on the observation that the fall in the postoperative diastolic pressure is greater and seems to be maintained longer than in the less extensive procedure recommended by Smithwick." Approximately 150 patients have now been subjected to the extensive thoracolumbar sympathectomy and the preliminary observation quoted above has been substantiated by follow up analysis of six, twelve and eighteen months. However it was further stated that "it is entirely possible that experience will show that the extensive two stage sympathectomy will be worthwhile only in a few selected patients."

We believe that careful evaluation of forty eight patients followed for twelve to eighteen months confirms the possibility quoted above and that the extensive sympathectomy should be reserved for hypertensive patients of the younger age group whose general evaluation shows only minimal or moderate damage to the cardiovascular system. If marked change to any of the three vital organs—brain, heart or kidney—has occurred, then the classical Smithwick operation consisting in removal of the sympathetic chain from the eighth or ninth thoracic through the second or third lumbar vertebrae should be employed.

The conclusions mentioned above have been drawn as a result of an analysis of the following data. We have compared the results of forty eight patients who had undergone the extensive thoracolumbar sympathectomy with sixty nine patients<sup>3</sup> who had been subjected to

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the classical Smithwick procedure. The data for comparison were obtained from each patient at the end of one year postoperative follow up examination. Only a very small number of patients with an extensive sympathectomy have been followed eighteen months and for that reason a comparison was made only at the end of one year.

Table 1 compares the effect of the Smithwick procedure and the extensive sympathectomy on the postoperative diastolic blood pressure. In each patient the resting and post exercise diastolic blood pressure<sup>1</sup> have been averaged. Only one-fourth of the patients

TABLE 1

NUMBER OF CASES IN WHICH THE POSTOPERATIVE DIASTOLIC BLOOD PRESSURE IS BELOW 100 MM. OF MERCURY (ONE YEAR FOLLOW UP)

	Number		
	Total	below 100	Per Cent
T 8 or 9 through L 2 or 3	69	18	26
T 3 or 4 through L 2 or 3	48	26	54

following the less extensive operation had diastolic blood pressure levels below 100 mm. of mercury. On the other hand more than one half of the patients had their diastolic pressure below 100 mm. of mercury following the extensive operation. The vast majority of patients in both groups had preoperative diastolic pressures of 125 mm. of mercury or more.

Table 2 shows the relative percentages of Group 1 and Group 2 Smithwick diastolic blood pressure results. A Group 1 result represents a fall of 30 points or more from the preoperative diastolic

TABLE 2

NUMBER OF CASES OBTAINING SMITHWICK GROUPS 1 AND 2 DIASTOLIC BLOOD PRESSURE RESULT (ONE YEAR FOLLOW UP)

	Number of		
	Total	Groups 1 and 2	Per Cent
T 8 or 9 through L 2 or 3	69	33	48
T 3 or 4 through L 2 or 3	48	36	75

pressure and a Group 2 result represents a fall of 20 to 29 points. Again it is clear that the extensive operation is more effective in lowering the blood pressure.

From this point on however comparisons between the two operative procedures begin to favor the less extensive Smithwick operation. Table 3 shows the number of patients in each group moderately or markedly improved at the end of one year and in each instance the figure is 90 per cent. In deciding whether a patient is markedly or moderately improved or unimproved we base our conclusions on the following



data (1) whether the preoperative symptoms have disappeared, (2) the blood pressure result, (3) comparison of preoperative and post operative roentgenograms, electrocardiograms and fundal examinations and (4) on the patient's subjective evaluation of the operation

TABLE 3

NUMBER OF CASES WHICH ARE MARKEDLY OR MODERATELY IMPROVED  
(ONE YEAR FOLLOW UP)

	Total	No Moderately or Markedly Improved	Per Cent
T 8 or 9 through L 2 or 3	69	62	90
T 3 or 4 through L 2 or 3	48	43	90

\* . . . . . = . . . . . has obtained

TABLE 4

NUMBER OF CASES SUBJECTIVELY IMPROVED (ONE YEAR FOLLOW UP)

	Total	Number Subjectively Improved	Per Cent
T 8 or 9 through L 2 or 3	69	58	84
T 3 or 4 through L 2 or 3	48	38	73

mitted to the extensive sympathectomy consider themselves improved and the operation worthwhile

Finally in Table 5 the number of deaths in the hospital in 100 consecutive cases in each group are compared. In both of these series the operations were done before the establishment of a set of rules which

TABLE 5

IN HOSPITAL MORTALITY RATE IN 100 CONSECUTIVE CASES IN EACH GROUP

	Cases	Number of Deaths	Per Cent
T 8 or 9 through L 2 or 3	100	3	3
T 3 or 4 through L 2 or 3	100	6	6

have proved helpful in the elimination of the majority of bad risk patients.\* If the rules had been employed in the above two series the mortality rates would have been halved. We are fully aware that experienced and sound clinical judgment must go hand in hand with the practical application of the rules

In conclusion, it is evident that the extensive sympathectomy which includes removal of the sympathetic chain from T 3 or 4 through L 2 or 3 has a more profound effect on the postoperative diastolic blood pressure than the classical Smithwick sympathectomy of T 8 or 9 through L 2. On the other hand, the less extensive operation has a lower in hospital mortality rate and more patients are pleased with their condition than with the extensive sympathectomy. We believe that the more radical procedure is valuable in good risk patients of the younger age group while all others should have the typical Smithwick thoracolumbar sympathectomy.

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## SURGERY IN PERIPHERAL VASCULAR DISEASE

HARRIS B. SHUMACKER, JR., M.D.\*

It is my purpose in this communication to discuss general principles in the treatment of peripheral vascular disease and the application of some of the commonly used surgical measures. I shall make no effort to present the detailed management of patients suffering from these disorders nor to consider all of the operative procedures of value. It is my hope that this approach will not convey the impression that I hold lightly the importance of the most minute attention to details in the prevention, diagnosis and treatment of the peripheral vascular disorders. At the risk of oversimplification, however, I feel that it is important to discuss certain broad principles which form the basis for the proper understanding and treatment of these difficulties.

It should be made clear at the beginning that the surgical treatment of peripheral vascular disorders implies the judicious utilization of indicated operative procedures in addition to all helpful nonoperative measures, in no sense does it eliminate the necessity for careful application of proven nonoperative aids. Any surgeon who neglects these fundamental measures does an injustice to his patient. For example, the most brilliant result of sympathectomy in thromboangitis obliterans is almost certain to fail in the long run if the patient is not forbidden the use of tobacco, made to take zealous care of the skin

surgery obviously would produce a better result. It is unfortunate that a sort of barrier has arisen separating so called medical and surgical therapy. Operative intervention is simply one means of treatment and should be advised when indicated, and in no other circumstances regardless of the special interest of the attending doctor, whether he be physician or surgeon.

It is also most unfortunate that there has arisen in the minds of many an illogical and erroneous concept linking "conservative" to nonoperative treatment and "radical" treatment to operative measures. This same loose usage has, furthermore, resulted in an association of "good" with conservative, and "bad" with radical treatment. One of

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the medical dictionaries\* has well defined conservative as "aiming at the preservation of health or at the restoration and repair of parts and function," and radical as "directed to the cause, going to the root or source of a morbid process." Used thus in more proper fashion both are commendable and desirable methods of treatment, and in ideal circumstances radical therapy is at the same time conservative.

It is unfortunate that the real cause of most of the peripheral vascular disorders is unknown and hence a fruitful program of radical treatment in such cases cannot be planned intelligently. In a few exceptional conditions such treatment is possible. Direct attack upon a peripheral aneurysm or arteriovenous fistula with surgical extirpation of the lesion is proper radical treatment, and if correctly done with avoidance of injury to collateral channels and with preservation or restoration of blood flow through the affected artery when possible such treatment is obviously conservative too. Since conservative treatment is that which offers the greatest chance for conserving the patient's life and limb and maximal functional utility of the diseased part, which conserves his time and money and which restores him to a useful productive life with greatest promise for continued well being it is the correct and indicated treatment in all circumstances. It may be medical or it may be 'surgical.' The most conservative treatment may necessitate the most extensive operation, and the least conservative may utilize only nonoperative measures. To amputate a limb at the thigh when a toe amputation would suffice is certainly not conservative. To perform a thigh amputation however, when there is hopeless gangrene of the foot and insufficient circulation for healing of a stump at a lower level is obviously the most conservative approach. To allow continued disability and progression of symptoms under ineffectual medicinal or physiotherapeutic treatment in a patient with severe Raynaud's disease when sympathectomy would likely bring about prompt relief of symptoms is not conservative treatment. Nor is it conservative to carry out some ill advised operation in a case of posttraumatic vasomotor disorder initiated or perpetuated by neuropsychiatric factors in lieu of the essential program of psychotherapy active exercise and when indicated elastic support.

#### LIMITATIONS IN THE PREVENTION AND TREATMENT OF PERIPHERAL VASCULAR DISEASES

It must be recognized that certain limitations in the prevention and treatment of these disorders exist. The precise etiology of most of these disorders and are, therefore, powerless

\* Dorland W. A. The American Illustrated Medical Dictionary 21st ed. Philadelphia W. B. Saunders Co., 1947.

## SURGERY IN PERIPHERAL VASCULAR DISEASE

HARRIS B. SHUMACKER, JR., M.D.\*

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It should be made clear at the beginning that the surgical treatment of peripheral vascular disorders implies the judicious utilization of indicated operative procedures in addition to all helpful nonoperative measures. In no sense does it eliminate the necessity for careful application of proven nonoperative aids. Any surgeon who neglects these fundamental measures does an injustice to his patient. For example, the most brilliant result of sympathectomy in thromboangiitis obliterans is almost certain to fail in the long run if the patient is not forbidden the use of tobacco, made to take zealous care of the skin

who considers resort to operative aid as a therapeutic failure and who continues ineffectual or less effective medical treatment when surgery obviously would produce a better result. It is unfortunate that a sort of barrier has arisen separating so-called medical and surgical therapy. Operative intervention is simply one means of treatment and should be advised when indicated and in no other circumstances, regardless of the special interest of the attending doctor, whether he be physician or surgeon.

It is also most unfortunate that there has arisen in the minds of many an illogical and erroneous concept linking "conservative" to nonoperative treatment and "radical" treatment to operative measures. This same loose usage has furthermore resulted in an association of "good" with conservative and "bad" with radical treatment. One of

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It is hoped that the extent of such measures may be increased in the future.

A third limitation in treatment concerns the common delay in seeking medical advice. Many of the chronic vascular disorders have an insidious onset and as a general rule patients fail to appreciate the significance of the initial complaints. The acute vascular catastrophes in which urgency of treatment is paramount usually occur without any forewarning. The resultant delay in obtaining proper treatment is of serious moment. It is perfectly apparent that the chance of success is considerable in the case of an embolus of recent origin and relatively hopeless after some time has elapsed. A small infected vesicle on the toe of a diabetic patient may prove a small therapeutic problem, while the chance of preserving the foot may be lost once extensive gangrene has ensued. Only through education of the public can the vascular disorders be seen and treated at their onset. A closely related problem concerns the failure of many patients to appreciate the seriousness of the situation. The same individual who would readily accept any proffered suggestion if he were told he had heart disease is apt to refuse all treatment once he has recovered promptly from a small area of superficial phlebitis occurring as the first symptom of thromboangitis obliterans. In such situations it is imperative that the physician use all his persuasive powers.

Thus far I have discussed certain limitations which pertain to the disease processes and to the individuals who suffer from them. There are also, unfortunately, certain limitations which arise as a direct failing of the medical profession. The first concerns a too widespread lack of understanding of the method of obtaining a vascular history and of performing a physical examination. The second concerns the lack of diagnostic skill in me.

One encounters physicians who have apparently never been taught the proper palpation of the peripheral pulses, the examination for and interpretation of color changes, the detection of incompetency of the valves of the venous system, and such simple procedures as the reactive hyperemia and reflex vasodilatation tests. There is nothing mysterious about the diagnosis of the peripheral vascular disorders. Though various instruments for the measurement of temperature and blood flow are of great value in the investigation, the diagnosis of these disorders can be made by the proper treatment outlined with no special equipment other than the physician's own personal endowments. The simple adjuvants which may prove useful at times are readily available to him—an aneroid sphygmomanometer, a rubber tourniquet, blankets and hot water bottles, needles, syringes and procaine. So long as vesicles, calluses and ingrowing toenails are treated without inquiry into vascular status

to prevent them. There are exceptions, to be sure, such as the traumatic injuries to the vascular system, frostbite and trench foot, and the vasospastic phenomena following the use of the pneumatic hammer. It is also true that there are other difficulties, the exact mechanism of origin of which is only partly understood but for which fairly reliable prophylactic measures are available. In this category may be listed the thromboembolic difficulties which are prone to occur after operation or in patients necessarily confined to bed. The common disorders, however, such as thromboangitis obliterans, arteriosclerosis and Raynaud's disease will undoubtedly occur as long as our fundamental knowledge of their origin remains obscure. If we are handicapped in the prevention of many of the vascular disorders we are, however, fortunately in a position to do much to forestall the development of many of their distressing accompaniments and sequelae. This general lack of knowledge of the etiology of many of the peripheral vascular disorders not only handicaps one in their prevention but also in their active treatment. This is particularly true since many of them are characterized by a diffuse rather than a local disease process and all too often one progressive in nature. In such conditions we can set as our goal relief of symptoms, restoration of function and prevention of annoying and disabling consequences, but we can hardly aim for a cure in the true sense of the word.

Another limitation which must be recognized is the fact that in

orders, for example, may result in a remarkably complete restoration of proper function. The thrombosed artery in arteriosclerosis or thromboangitis obliterans is, however, forever occluded. The thrombosed vein may recanalize but not with preservation of a competent valvular system. The foot that has become gangrenous from ischemia cannot be saved. Treatment must therefore be undertaken with full realization of the permanent damage that has already taken place. Thus much of therapy in these disorders is necessarily supportive or corrective rather than restorative or reparative. While recognizing the limited nature of present day treatment we must keep constantly in mind the possibility of favorably altering future treatment through experimental and clinical investigation. We must also keep in mind

that we must take advantage of and offer opportunities to cite the principal peripheral vessels. Another example is the restoration of blood flow through the involved artery in cases of aneurysm or arteriovenous fistula by such measures as transfixion and division of the fistula, lateral arteriorrhaphy, end-to-end anastomosis or vein transplantation.

limbs affected with the common peripheral vascular disorders is generally beneficial. Active sweating increases heat loss through evaporation and consequently has an effect of reducing the effective circulation. Sweating may lead to maceration of skin and may favor development of fungus infections both of which may be factors in the development of ulceration, pyogenic infection or gangrene. Cessation of sweating therefore affords an additional safeguard in such cases.

A second effect concerns the abolition of certain types of pain, as for example the ischemic pain in obliterative disease or after traumatic or other sudden occlusion of important arteries and the pain of causalgia and certain other posttraumatic states. One can never assume that pain will be relieved by sympathectomy but must first demonstrate that the pain ceases or improves satisfactorily during a period of pathetic cold at a time

cold or upon standing or walking the patient should be tested under such conditions during sympathetic anesthesia. If these preoperative studies are carefully performed and evaluated the results of sympathectomy in painful states will be excellent. No therapeutic achievement is more gratifying than the cessation of the pain of severe major causalgia after sympathectomy. Not infrequently the pain of minor causalgia and of the other posttraumatic visomotor states can be relieved by this procedure. It goes without saying however that encouragement of the patient to use the affected part actively, the employment of elastic support when needed and of appropriate local surgery when indicated should be given a trial beforehand. In some instances ischemic rest pain is dramatically relieved by sympathetic interruption but this is not always the case. Rarely is intermittent claudication of the calf muscles affected appreciably. Sympathectomy is more apt to provide striking results when claudication is present in the small muscles of the feet. The pain felt on exposure to cold in various vasospastic states generally responds well to sympathectomy. In certain of these painful conditions relief of pain following sympathetic denervation obviously depends upon resultant increase in blood flow. In other conditions, for example in major causalgia, there is no conclusive evidence to signify that the relief of pain is dependent upon alterations in circulation.

The effect of sympathectomy upon which its maximal usefulness is based is the elimination of vasoconstrictor impulses with resultant vasodilatation. The possible improvement in circulation can be gauged beforehand fairly accurately by careful observation of the warmth and color of the affected hand or foot following some procedure which temporarily eliminates the vasoconstrictor impulses—reflex vasodilatation, spinal or general anesthesia, peripheral nerve block or sym-



of the limb so long as arch supports are prescribed as the sole means of therapy in unrecognized obliterative disease so long as causalgia and other posttraumatic states are neglected under the confused impression that they are examples of "hysteria" the best chance for prompt and satisfactory treatment and the avoidance of disabling sequelae will be lost

An occasional related failing of the medical profession concerns a lack of appreciation of the gravity of the situation imposed by significant reduction in blood supply. Practitioners who would not undertake to operate upon an aneurysm or perform a sympathectomy often unhesitatingly do toe amputations in the presence of marked ischemia. My experience in the training of surgeons convinces me that it is far easier to teach the proper execution of the major operative procedures used in vascular surgery than it is to convey a real sense of clinical judgment in regard to the so called minor procedures and a proper understanding of the preoperative, the operative and the postoperative care that is essential.

There can be no doubt then that there are definite limitations under which the surgeon labors in this field. In spite of these limitations there are great possibilities of real help to patients suffering from peripheral vascular disorders. These possibilities will now be considered by discussing some of the common surgical operations which are applicable.

### SURGICAL PROCEDURES

**Sympathectomy**—One of the most useful procedures is that of sympathectomy. The operation of lumbar sympathetic gangliectomy is performed easily through an anterior muscle-splitting extraperitoneal approach. The first step is to make a vertical incision in the skin over the lumbar region, usually between the third and fourth lumbar vertebrae. The incision is made through the skin and the superficial fascia, and then through the external oblique muscle. The incision is then extended laterally and superiorly, following the line of the muscle fibers. The external oblique muscle is then split, and the intercostal space is entered. The sympathetic ganglia are then identified and sectioned. The operation is performed after resection of the

\* The first deals with absence of sweating. It is this effect which constitutes the primary reason for sympathectomy in cases of severe hyperhidrosis or bromhidrosis. The results are extremely gratifying. It is fortunate that the absence of sweating in

subsides slowly it may be advantageous to use local refrigeration, a procedure which I feel should be limited to cases in which one is committed to an amputation

Closed amputations are preferable to open amputations. Unfortunately closure of the stump is often impossible or inadvisable in toe amputations because the gangrenous process leaves no adequate tissue for approximation, or because infection is present in too close proximity to the site of amputation. In such cases the open stump must be kept clean, and drying must be prevented. Relatively ischemic tissue tends to die when allowed to dry out. Sterile saline compresses may be alternated with application of a bland ointment, omitting the former whenever maceration of skin seems threatened. Closed amputation stumps should not be drained in general, but should be sutured snugly with accurate approximation of skin edges after making certain that good hemostasis has been secured. It is important in preparing the area for surgery that mild and preferably colorless antiseptics should be used. One can take no risk with blistering the skin and it is unwise to mask the natural color of the skin. Every effort must be made to handle tissues with extreme care. The skin should not be grasped with forceps. A tourniquet should never be employed. Healing may be delayed, consequently sutures should be left in place longer than is usually necessary.

In general the same sites of election for amputation prevail in peripheral vascular disease as in other conditions, taking into consideration, of course, the fact that certain types of operation require long flaps and are of necessity not applicable when the blood supply is not adequate. Except in the very weak and elderly in whom it is perfectly obvious that a prosthesis will never be worn, it is preferable to preserve the knee, if possible. One should not be too pessimistic about the elderly patient's will and ability to use a prosthesis, many such individuals learn to use them readily enough. Many tests and observations are important in determining the proper site for amputation. The presence of good oscillometry and of major pulsations at the level of amputation are not essential for good healing. The most reliable index of sufficient circulation at any given level is the presence of obviously satisfactory vascular supply upon sectioning the tissues.

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level. For amputations  
ler type of operation is

excellent

**Plastic Procedures**—Plastic procedures have limited applicability in cases of severe obliterative disease. Leg ulcers in such cases often

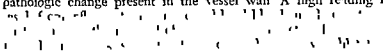
pathetic block Such tests should preferably be performed in a room maintained at a fairly constant temperature and which is cool enough so that the acclimated extremity will not be in full vasodilatation before the block is accomplished Under such conditions a transient increase in circulation to a state of maximal vasodilatation will occur in purely vasospastic conditions and a similar permanent change can be anticipated following sympathectomy In cases of obliterative disease the improvement in circulation may be great moderate small or insignificant, depending upon the prevailing tonus in the unobstructed vessels The efficacy of sympathectomy in these cases is roughly related to the degree of improvement in circulation which it accomplishes In certain individuals however, in whom little or no apparent improvement has followed sympathetic block, the small increase in circulation achieved by sympathectomy has been sufficient to save a limb and to abolish pain In addition to the usual vasospastic disorders and the common obliterative diseases sympathectomy is often useful in rendering the collateral circulation more efficient in cases of ligation thrombosis or embolic occlusion of major arteries and as an adjuvant in the operative treatment of aneurysms and arteriovenous fistulas Sympathectomy is the method of choice in any case in which continued maintenance of the maximal possible vasodilatation is desirable

**Crushing of Sensory Nerves**—The crushing of appropriate peripheral sensory nerves is a valuable aid in controlling severe intractable

sistent and cannot be controlled by nonhabit forming sedatives or by sympathetic interruption, the sensory nerves to the painful area should be crushed

**Amputation**—No surgical procedure requires more careful judgment or more precise and gentle operative technic than amputation in patients with peripheral vascular disease In order to avoid needless loss of limb one must be certain that every measure to increase the blood flow to the part has been taken Amputation is an irrevocable step and not to be taken except when justified In order to minimize the hazard of infection in the stump every precaution should be observed to eliminate or decrease local infection The firm dry appearance of the ischemic area does not necessarily signify absence of infection all too often such areas of "dry" gangrene merely mask an underlying pool of pus If infection is present, chemotherapeutic agents and antibiotics are of great help Abscesses should be incised and drained Sterile compresses applied at a temperature not exceeding body temperature are generally advisable If the infection persists or

depend upon the degree of patency of either the main artery or collateral circulation or both which is synonymous with the degree and type of pathologic changes in the walls of the arteries. For patients with various vascular disorders the curves may be within above or below the range of normal readings. The very low curve may be due to thrombosis caused by arteriosclerosis, thromboangitis obliterans, endarteritis and other similar pathological conditions and emboli. The degree of obstruction is dependent upon the degree of pathologic change present in the vessel wall. A high reading may



in erythromelalgia.

Use of this procedure has reportedly been of great assistance to one of the authors in determining the site of amputation below the knee when the main arteries were not palpable. It has enabled him to perform a modified guillotine type of amputation with primary wound closure<sup>5</sup> thereby preserving the knee joint. The preservation of the knee joint in patients with peripheral vascular disease is of inestimable benefit to them as compared to any type of thigh amputation.

As stated in a previous paper<sup>5</sup> we still do not attach as much clinical importance to the circulation time as might be the case were environmental conditions of temperature and those of the patients more constantly controlled. However a marked variance, either a quickening or delay in the circulation time, as cited is of more upon extracellular

active sodium as an indication of the extent and the type of circulation present. In our charts plotted in terms of the number of hundred counts per minute per hundred microcuries of radioactive sodium we have come to distinguish the graphs in groups of I, II, III and IV. No. I being well below normal, No. II being just below normal, No. III lies within the normal range and IV above normal. If a part of the curve lies within another group the graph is labeled of the group in which most of it lies and a minus or plus sign is added to signify within what other group it lies.

All cases of hypertension in Group III or over have not done well with thoracolumbar sympathectomy. We regard this group as a contraindication to operation. Group II hypertensives do not all do well. This reading as an indication for or against operation should be evaluated with clinical and laboratory findings. The entire subject of this test in relation to operations in essential hypertension will be discussed in a paper now in preparation.

## RADIOACTIVE SODIUM IN PERIPHERAL VASCULAR DISEASE STUDIES

BEVERLY C. SMITH, M.D., F.A.C.S. AND EDITH H. QUINTBY, Sc.D.

RADIOACTIVE sodium was first used by us for diagnostic purposes in peripheral vascular diseases at Presbyterian Hospital in 1943. We have used it in approximately eight hundred cases. This isotope as previously reported has given diagnostic, prognostic and therapeutic information of a high degree of accuracy which has been of great benefit to patient and clinician. We have varied our technic very little since the original report on this method in 1944<sup>1,2</sup> and subsequent reports in 1945<sup>3</sup> and 1947.<sup>4</sup>

Our sodium is prepared, as originally reported, in the cyclotron at Columbia University one day, measured and autoclaved and used clinically the next day, so that its relatively short half life of 14.8 hours has not been a problem in our particular case.

In studies of peripheral vascular disease in the feet and legs, the patient lies on his back with his feet well separated. The counter is placed against the sole of the foot and a measured amount of radioactive sodium, usually about 100 microcuries, in 3 to 7 cc of sterile normal saline, is injected into an antecubital vein. Precautions are taken to see that all of the material gets into the vein and that neither the patient nor the injector is contaminated by it, if the latter is going to handle the counter. The times of the beginning and end of the injection are noted. Registration of the arrival of the radioactive material at the sole of the foot is made by an audible signal from the Geiger counter, which has an adjustable circuit so that the counting

material traverses the circulatory system and reaches the foot the counting rate increases sharply, in this manner the actual arm to foot circulation time can be measured.

As the radioactive sodium leaves the capillaries and enters the extravascular fluid in the foot, build up to equilibrium is manifested by the increase in counting rate. The "build up curve" is plotted in counts per minute for thirty to forty five minutes, starting immediately after the injection. The rate of build up and its final result



tions in the right foot. The patient has responded well to three years of conservative therapy without local infections.

Radioactive sodium tests (Fig 90) on June 22, 1944, show a very low reading in the left foot which was the same on April 1, 1945. However, on July 12, 1946, there had been a rise into and above the normal range which, in the absence of palpable arteries, was interpreted as an increase in collateral circulation. This coincided with a clinical improvement. On May 15, 1947, the two feet were about equal in the low normal range. Between 1944 and 1946, the patient received seventy physiotherapy treatments of whirlpool baths, massage, pressure suction boot and continued a home regimen of elevation depression exercises, warm soaks and massage. This test discloses the degree of collateral circulation present in extremities without palpable arteries and its response to treatment. The right had previously been higher than the left. At this time the symptoms and claudication in both extremities were about the same. The blood supply of both had again diminished—the right more than the left.

### Case II

A S (560418), a 69 year old man, was admitted to the Presbyterian Hospital on September 7, 1938 complaining of intermittent claudication for ten years.

## Oscillometry

	Right	Left
Lower third of leg	7.0	2.5
Upper third of leg	15.0	6.0
Lower third of thigh	20.0	10.0

hypertensive cardiovascular disease and generalized arteriosclerosis

On August 31, 1943, both feet gave readings in Group II

A test on October 31, 1945 showed both feet had risen into normal range (Grade III) (Fig 91) Either following treatment or spontaneously more collateral circulation had developed two years after the first test. He has had no infections in his digits. He is clinically improved.

### Case III

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## RADIOACTIVE SODIUM CIRCULATION TEST

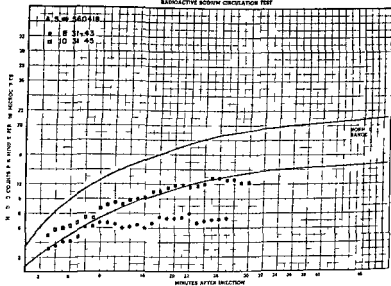


Fig 91 (Case II) —See text

## RADIOACTIVE SODIUM CIRCULATION TEST

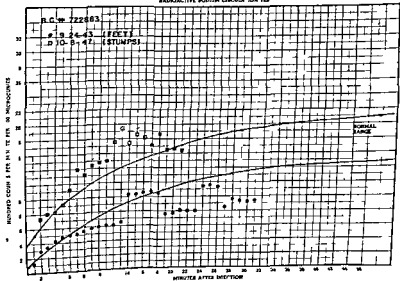


Fig 92 (Case III) —See text.

admission he had extreme discomfort in both lower extremities while at rest. All of his right lower extremity arteries were palpable but only the femoral was palpable on the left.

# OSCILLOMETRY

	Right	Left
Lower third of leg	1.0	plus-minus
Upper third of leg	2.5	2.5
Lower third of thigh	3.5	1.25

The radioactive sodium test was done before and after posterior tibial nerve block at the internal malleolus (Fig 94, 1). It showed a rise in the right foot but no rise in the left foot after a nerve block, indicating the degree of arterial response possible in the two legs to treatment. The patient improved greatly with treatment and became able to walk four blocks without discomfort. He died in July 1947 of a coronary thrombosis.

# Case VI

A. M. (584036) a 61 year old woman, with moderately severe diabetes accompanied by generalized arteriosclerosis and gangrene of the right second toe, was first

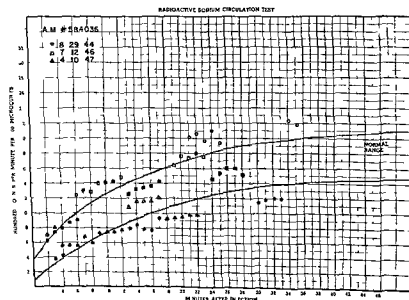


Fig 95 (Case VI) - See text

Fig. 91-J

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100

afternoon. She had a number of infections in the skin of various toes and web spaces which responded to not too vigorous local treatment.

A radioactive sodium test (Fig. 93) on July 9, 1943 showed a very low reading (Grade I). This coincided with her cold, red, right foot without palpable arteries. Her infections were treated as major surgical problems. Toe amputations and infections required from six to eight months to heal. They have remained healed.

A radioactive sodium test on May 22, 1947, four years after extensive, prolonged treatments to her feet, showed a very high reading (Grade IV). This is the result of increased collateral. Her feet have remained healed.

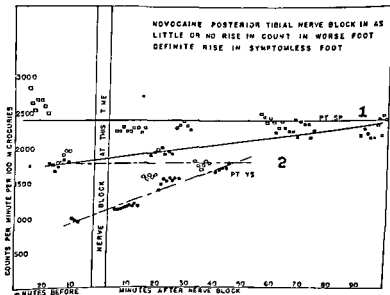


Fig. 91-J, Case V, 2, Case I See text

### Case V

S. P., a 61 year old man with severe diabetes accompanied by generalized arteriosclerosis was first treated May 25, 1933. X rays showed calcification in the abdominal aorta, none in the iliacs and traces of calcium in the walls of the femorals and left posterior tibial arteries. The arteries in the feet did not show calcification. On

admission he had extreme discomfort in both lower extremities while at rest. All of his right lower extremity arteries were palpable but only the femoral was palpable on the left.

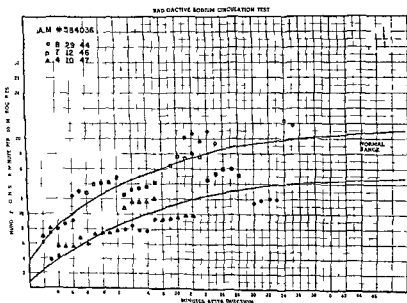
## OSCILLOMETRY

	Right	Left
Lower third of leg	1.0	plus-minus
Upper third of leg	2.5	2.5
Lower third of thigh	3.5	1.25

The radioactive sodium test was done before and after posterior tibial nerve block at the internal malleolus (Fig 94, I). It showed a rise in the right foot but no rise in the left foot after a nerve block, indicating the degree of arterial response possible in the two legs to treatment. The patient improved greatly with treatment and became able to walk four blocks without discomfort. He died in July 1947 of a coronary thrombosis.

## Case VI

A. M. (584036), a 61 year old woman, with moderately severe diabetes accompanied by generalized arteriosclerosis and gangrene of the right second toe, was first



admitted on June 26, 1941. In 1935 a cataract was removed from her right eye and in October 1938 one was removed from her left eye. In July, 1939 the left eye was enucleated because of iridocyclitis following incomplete cataract operation in 1938.

A series of operations for infections in her feet occurred as follows

- 6/27/41 Amputation of right 5th toe for gangrene.
- 7/20/41 Amputation of right 2nd toe for gangrene
- 2/19/42 Amputation of right 1st, 3rd and 4th toes for gangrene
- 6/30/44 Amputation of left 4th toe for gangrene

The right foot has remained healed since April, 1942 and the left foot since August, 1944. She walks without discomfort in either foot as far as she desires.

The radioactive sodium tests (Fig 95) done after right toe amputations showed a very good circulation in both feet which, in the absence of palpable vessels, indicates that collateral circulation has made this result possible. We have no records of tests made on this patient prior to toe amputations. The radioactive sodium test on August 29, 1944, two and one half years after amputation of all five right and the fourth left toes, showed the right foot to be a high Grade II and the left a Grade IV. The right foot with the distal transmetatarsal amputation had remained healed, symptomless and was completely useful. The left foot contained residual inflammation. A second test done on January 30, 1945, showed the right foot to be a Grade IV, the same as the left foot which had remained healed with her condition.

### Case VII

R. L. (86-950) a woman aged 22 was admitted to Presbyterian Hospital on

... revealed extreme vasodilatation which was evidently the result of ... following division of the sciatic nerve. A second test on July 1, 1947, one month after the second operation, revealed that the circulation in the right and left feet was equal and Grade II even though there was no clinical evidence of nerve degeneration. The ulcers on the right sole had been healed for two months.

## RADIOACTIVE SODIUM CIRCULATION TEST

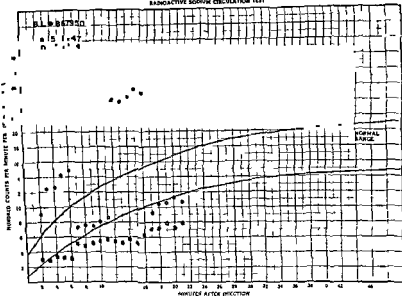


Fig 96 (Case VII) -See text

## RADIOACTIVE SODIUM CIRCULATION TEST

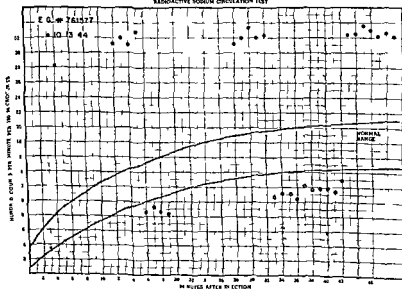


Fig 97 (Case VIII) -See text

## Case VIII

E. G., a 63 year old, obese diabetic, arteriosclerotic woman has had diabetes for fifteen years which has been poorly controlled by diet and insulin. In August, 1944, she pulled a callus off the sole of her right foot, the site became infected and has remained so. X rays on October 6, 1944, showed no calcification in her abdominal aorta but calcification in the walls of the iliac, femoral, popliteal and posterior

the diagnosis of either a neurotrophic or tuberculous joint was considered. The femoral popliteal posterior tibial and dorsalis pedis arteries were normally palpable in both lower extremities. Wound cultures showed hemolytic *Staphylococcus aureus*. She was given 80,000 units of penicillin daily for six days. On October 18, 1944, sequestrectomy was done on the right second toe, right second and fifth metatarsals and right cuboid. One month after this procedure she was discharged cured and has remained so. X rays on March 28, 1947, show recalcification of bones of tarsus, repair of irregularities in heads of metatarsals, healed metatarsal amputation sites and a general remarkable reparative ability as regards all the bones in the right foot.

A radioactive sodium test (Fig. 97) done on October 13, 1944, showed a Grade II curve in the left, unaffected foot, but a Grade IV plus curve in the inflamed right foot in which the dorsalis pedis artery was palpable. The chart is vivid evidence of the effect of inflammation on blood supply in a part with an existing unimpaired arterial supply.

## Case IX

A radioactive sodium test (Fig. 98) done on November 14, 1946, showed a very low reading (Grade I plus) in both feet in spite of

5, 1946, a week after the right lumbar sympathectomy, showed an appreciable rise from a Grade I plus to a Grade III minus curve.

## RADIOACTIVE SODIUM CIRCULATION TEST

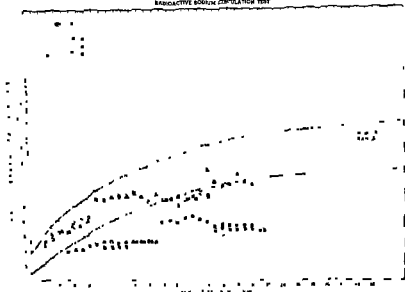


Fig 98 (Case IX) -See text

## RADIOACTIVE SODIUM CIRCULATION TEST

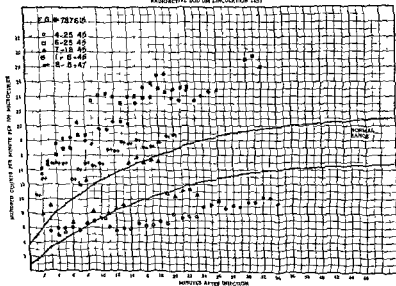


Fig 99 (Case X) -See text



## Case X

changes without hemorrhages, exudate or edema. His genitourinary tract showed no abnormality and his kidney function was normal. On May 31, 1945 a right thoracolumbar sympathectomy from T 9 to L 2 inclusive was done. His con-

A radioactive sodium test (Fig 99) preoperatively on April 25, 1945, showed a Group II curve in the feet which, in the presence of normally palpable arteries, was thought to represent arterial spasm. A second test on June 25, 1945, three weeks after the right operation, showed a marked bilateral vasodilatation to Grade IV. The rise in the unoperated side is explained by interruption of cross innervation. A third test on July 18, 1945, the day of the second operation, showed a marked reduction of each curve to a low Grade IV in the right operated side and a greater reduction to Grade III minus in the unoperated side. This reduction, we feel, is associated with the patient's anxiety associated with his operation two hours after the test. A fourth test on January 8, 1946, showed the circulation of both feet

operatively the radioactive sodium test showed peripheral spasm of a Grade II which was released by bilateral thoracolumbar sympathectomy to a Grade IV which has persisted for two and one half years during which time the patient has remained clinically greatly improved and his blood pressure 160/110

## Case XI

A 42 year old woman was admitted to Presbyterian Hospital on February 1, 1945. She had a long history of hypertension. Her blood pressure was 180/110. Her urea nitrogen was 10.15 and showed a 3 plus albuminuria with rare granular casts. An electrocardio-

gram showed left axis deviation. Her phenolsulfonphthalein excretion was 30 per cent in two hours. Her cardiac, renal and cerebral pathologic changes were thought secondary to her hypertension and not the result of primary renal disease. On March 13, 1945, a left thoracolumbar sympathectomy from T 8 to L 2 inclusive was performed. A left kidney biopsy showed an advanced arteriosclerosis. Her postoperative course for the first two weeks was relatively smooth considering the magnitude of her widespread disease. Three weeks after operation she developed an encephalopathy with convulsions and died May 12, 1945, four weeks after operation. The significant anatomical autopsy diagnoses were:

Generalized arteriosclerosis  
Arteriolar nephrosclerosis  
Encephalomalacia—left temporal lobe  
Hemorrhage (old)—right frontal  
Broncho and lobular right and left pneumonia

The autopsy renal changes were those of arteriolar nephrosclerosis but the vascular glomerular changes were too mild to have caused anemia.

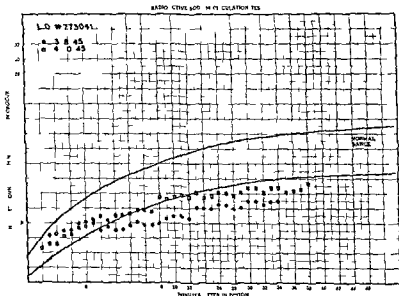


Fig. 100 (Case XI) See text

A radioactive sodium test (Fig. 100) done preoperatively on March 8, 1945, showed only moderate peripheral arterial constriction in the lower extremities (a high Grade II curve). A second test four weeks after operation showed practically no vasodilatation in the lower extremities (Group II plus) indicating as predicted preoperatively from the first test a poor clinical operative result which was substantiated by death four weeks after the first operation of cerebral thrombosis.

## Case XII

A.S. #603879

genitourinary studies failed to reveal significant findings. On admission her blood pressure was 190 systolic and 150 diastolic. An electrocardiogram on May 13, 1943 when compared with one on March 6, 1940 showed evidence of advancing cardiac muscle damage. Her fundi were classed as Grade II characteristic of essential hypertension. The fundi had not changed from 1940 to 1943. On November 15, 1943 a right thoracolumbar sympathectomy was done from T 9 to L 2 inclusive. On February 14, 1944, a left similar procedure was performed. The patient's blood pressure when discharged after an uncomplicated convalescence was 138 systolic and 90 diastolic prone and 110/80 standing.

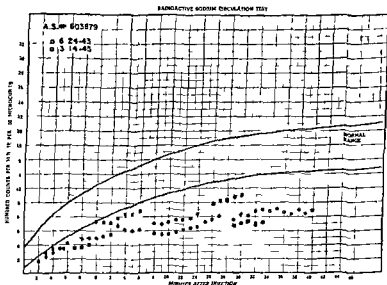


Fig 101 (Case XII) —See text.

A radioactive sodium test (Fig 101) done on June 24, 1943, pre-

operational constriction and operation, ations had not ctive and was tolic and 105 symptomatic. This low blood pressure after thoracolumbar sympathectomy in the presence of existing vasoconstriction will be discussed in a subsequent paper.

### Case XIII

E M, a woman aged 49, was admitted to the Neurological Institute on April 27, 1945, complaining of hypertension for fourteen years partial blindness in her left eye for two years and blurred vision in her right eye for one month. Her blood pressure on admission was 230 systolic and 130 diastolic. She had no significant cardiac, renal or cerebral manifestations by clinical or laboratory examination. The pathologic changes were minimal.

into shock during the operative procedure but passed with supportive treatments. On June 25, 1945 a similar operation was performed on the right, resecting the

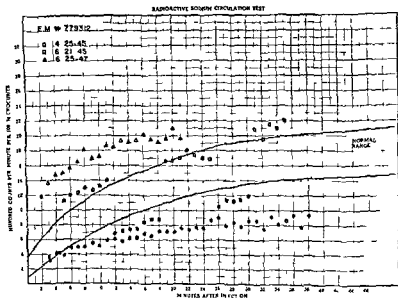


Fig 103 (Case XIII) —See text

sympathetic chain and splanchnic nerves from the right kidney showed a moderate developed auricular fibrillation with blood pressure was 175 systolic and 80 diastolic blood pressure recumbent was 170/70 or under tension. She has no heart failure. She is happy she was operated upon.

A radioactive sodium test (Fig 102) done preoperatively on April 25, 1945, showed moderate peripheral arterial spasm in her lower extremities (Grade II). During her amytal test her reading rose to Grade II plus with a drop in blood pressure from 245/120 to 170/70. A second test on June 21, 1945, following her left operation, showed

a release of peripheral vasoconstriction with a rise of the left lower extremity to Grade IV minus, the right remaining a little higher Group II A third test on June 25, 1947, two years after the second operation, shows a persistent release of vasoconstriction which corresponds to the absence of clinical symptoms and a blood pressure of 170/90

### Case XIV

J S (741571), a 24 year old female, admitted to Presbyterian Hospital on March 27, 1947, for hypertension, complaining of severe headaches for five years. Her blood pressure was 215 systolic and 145 diastolic. Her genitourinary examination revealed no abnormalities. Her heart was enlarged to the left. There was a presystolic gallop and a short localized apical systolic blow. The second aortic sound was markedly accentuated. An electrocardiogram showed signs of early myocardial damage characteristic of left ventricular strain. The fundi showed a Grade III hypertensive retinopathy without recent hemorrhages, exudate or edema. On March 31, 1945 a

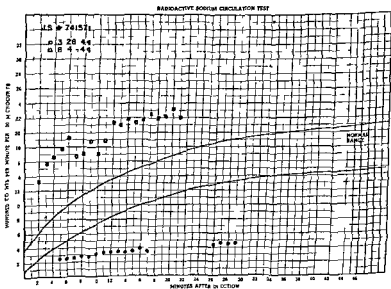


Fig. 103 (Case XIV) —See text

—normal A

A radioactive sodium test (Fig 103) done on March 28, 1944 before operations showed a marked peripheral vasoconstriction—Group I. A second test done on August 4, 1944, three months after her second operation showed a release of vasoconstriction to a high Group IV. The patient's symptoms of headache, precordial pain and dyspnea were completely relieved in spite of only a moderate fall in the blood pressure which remained at 180/160 standing and 230/180 sitting. She returned to her home outside of this country and resumed her house work. In January 1945 she became pregnant and upon advice was aborted by a hysterectomy in April. Her symptoms of precordial pain on exertion and pain in the back of her neck and head upon awakening began to return in October 1946 and on December 5, 1946 she died of a cerebral hemorrhage, two and one half years after her second operation. Bilateral thoracolumbar sympathectomies relieved this patient's symptoms without materially affecting her blood pressure. Her disease progressed. She was more comfortable until her death two and one half years after the operation. Before operation she was completely incapacitated by headaches.

#### Case XV

FIG. 104. RADIOACTIVE SODIUM TEST.

ALL RADIOACTIVE SODIUM TESTS WERE NORMAL. THE PATIENT WAS INCAPACITATED BY HEADACHES.

The radioactive sodium test (Fig 104) done preoperatively on January 31, 1945, showed evidence of marked peripheral vascular spasm (Grade I+). The test repeated two months after the first operation, on

April 10 showed a marked release of peripheral constriction in both lower extremities curve Grade IV from Grade I+. His blood pressure however at this time was 230/140. The histological structure of the right ganglia after the second operation was normal. The third test on May 22 1945 one month after the second operation showed a persistence of peripheral arterial dilatation in the lower extremities still Grade IV but a little less evidence of vasodilatation. His blood pressure at this time was 230/140 prone and 190/130 standing. A fourth test on March 1 1946 one year after the second operation showed

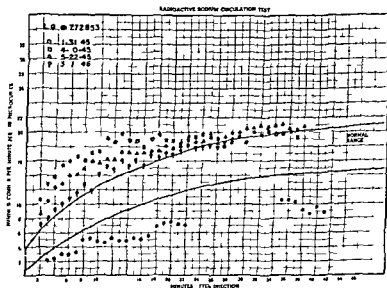


Fig 101 (Case XV) —See text

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extremity arteries but  
standing and 230/150  
he fact that he re-  
sistent hypertension

in the presence of peripheral vasodilatation will be discussed in a subsequent paper

This patient died in spite of released peripheral constriction. His blood pressure was not diminished yet his symptoms were relieved. His electrocardiogram improved then showed progressive myocardial disease. The operations relieved him from being bedridden—sufficiently to permit him to work for one and one-half years—but did not check his disease yet he was repeatedly grateful for the relief of his symptoms.

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## THE MANAGEMENT OF VENOUS THROMBOSIS AND PULMONARY EMBOLISM

STUART W COSGRIFF M D • RICHARD J CROSS M D †  
AND DAVID V HABIB M D †

THE purpose of this report is to present the experience of a group which has been intensively studying the management of venous thrombosis and pulmonary embolism during the past two years. The importance of this problem is indicated by the fact that the incidence of fatal embolism occurring as a complication of deep venous thrombosis ranges between 34 per cent and 57 per cent and that 11 to 18 per cent of patients who survive one pulmonary embolus experience a subsequent embolus which is fatal.<sup>1 2 3</sup> There has been considerable controversy in recent years as to the superiority of medical or surgical therapy in venous thromboembolism. Present mature judgment now tends towards the conclusion that both surgical and medical management have comparably reduced the fatalities due to initial and subsequent pulmonary emboli. Although admittedly not the complete solution to the problem either method is undoubtedly preferable to the "do nothing" or "expectant observation" school of management. The institution of anticoagulant therapy or the ligation of the peripheral deep veins are alternative methods one of which should be employed in practically every patient with deep venous thromboembolism if that individual is to receive treatment commensurate with present day medical knowledge.

A team composed of members of the Departments of Medicine and Surgery was organized to manage therapy in all cases of venous thrombosis and pulmonary embolism occurring in the Columbia Presbyterian Medical Center. The cases in this series were drawn from all services of the hospital. Anticoagulant therapy has been the usual method of treatment (in 254 cases) except for the infrequent instances (ten cases) in which anticoagulants were believed to be contraindicated or inappropriate because of a particular clinical situation.

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In these latter cases ligation of the appropriate peripheral deep veins was performed

The purpose of anticoagulant therapy is to prevent further intravascular thrombosis in the deep venous system and in this manner to reduce greatly the occurrence of pulmonary embolism. The cessation of pathological intravascular clotting is effected by producing only a partial inhibition of the normal clotting mechanism without necessarily rendering the blood totally incoagulable. Although it is agreed that heparin and dicumarol do not produce a dissolution of an organized thrombus, recently there has been evidence<sup>4,5,6</sup> that the early stage of an intravascular clot is an agglutinative mass of red blood cells and cellular debris, which under some circumstances can be dissipated by the antiagglutination action of the anticoagulant drugs. That portion of the thrombus material which remains as such after the

### ANTICOAGULANT THERAPY

Dicumarol<sup>7</sup> has been employed as the principal anticoagulant, with concurrent heparinization during the first twenty four to forty-eight hours to insure an immediate antithrombosing effect until such time as adequate prothrombin deficiency has been produced by dicumarol. Subsequently during the course of dicumarol therapy, heparin has also been used for periods of twelve to twenty four hours whenever the prothrombin time elevation became unsatisfactory.

**Heparin**\*—Heparin administration has been controlled by determinations of the venous blood clotting time performed according to the Lee-White<sup>8</sup> technic. Normal venous clotting times in this institution have ranged between five and twelve minutes. The patient's coagulation time is determined prior to starting treatment, following which heparin may be administered by any of several methods.

1 *Continuous Intravenous Infusion* Heparin sodium 100 mg., is placed in a 1000 cc. infusion. Initially the rate of flow is set at 25 drops per minute. A clotting time should be performed two hours after the start of the infusion and twice daily thereafter. The rate of flow is adjusted so as to maintain the clotting time between twenty and forty minutes. Murray<sup>9</sup> has employed this method in a large series and concluded that it is a dependable mode of administering heparin. This method of administration possesses the practical disadvantages to the doctor and the patient entailed in the maintenance of a continuous infusion for a period of ten to fourteen days and for this reason has not been frequently used by this group.

\* A portion of the heparin used in this study was supplied by the courtesy of Roche-Organon Inc., Nutley, New Jersey.

2 *Intermittent Intravenous Injection*—Heparin, 50 mg, is administered intravenously every four hours. The venous clotting time performed twice daily three to four hours following an injection of heparin may be normal, but should not be higher than thirty minutes. The Mayo Clinic group<sup>9,10</sup> has employed this method principally in their large experience.

3 *Heparin Pitkin Menstruum* \*—It has been reported<sup>12</sup> that 300 to 400 mg of heparin in this menstruum satisfactorily prolongs the venous clotting time for a period of approximately forty-eight hours. It has been our experience in a few cases that the effect on the coagulation time was inconstant and that considerable pain was caused at the injection site. However, Loewe<sup>4</sup> recently has reported that a dose of

by newer products

4 *Intermittent Subcutaneous Injection*—The authors have had the greatest amount of experience with the intermittent subcutaneous method of administration<sup>11</sup> which is believed to eliminate the more excessive fluctuation of coagulation time encountered with repeated intravenous injections and to allow for a more sustained effect. This method possesses one practical advantage in that the hypodermic injection of heparin is a nursing procedure. An initial injection of 25 or 50 mg of heparin sodium is given intravenously, followed within one hour by 50 mg administered into the deep subcutaneous tissues. Beginning three hours later the average maintenance dose of 30 mg subcutaneously every three hours is started. The coagulation time, determined two and one half to three hours after the third heparin injection (and twice daily thereafter at approximately two and one-half to three hours following a dose of heparin), should range between twenty and forty minutes, a safe but adequate anticoagulant effect. Significant discomfort necessitating discontinuance of heparin occurred in only one patient and there were only occasional victory continuous eleva  
95 per cent of patients

irred in 12 per cent of

When hemorrhage is encountered, three steps are available: (1) continuation of heparin temporarily or permanently (2) administration of relatively fresh whole blood transfusion in amounts of 500 to 1000 cc, which returns the excessively elevated clotting time towards normal (3) It has  
of 1 per cent  
the courtesy

solution administered intravenously) immediately neutralizes excessive circulating heparin and returns the clotting time to normal within five minutes of administration. No precipitation of acute intravascular clotting has been reported following use of protamine for this purpose. Inasmuch as heparin is excreted in part via the kidney<sup>15</sup> it should be administered cautiously to patients with renal insufficiency.

Anaphylactic reactions have been reported by Jorpes<sup>15</sup> to have occurred in four patients in the Swedish group. Two patients have been encountered in this series who within a few minutes following an injection of heparin sodium complained of sneezing and rhinitis, conjunctivitis and lacrimation. Neither of these individuals had received heparin previously. In one patient pyribenzamine in dosage of 100 mg three times daily prevented this allergic phenomenon although symptoms returned when the antihistamine was omitted during subsequent injections. This patient also complained of significant difficulty in expiration and a tightness across the precordium within a few minutes following injection. This symptom was believed to be due to bronchospasm and was unrelieved by the antihistamines. In the other individual although the initial intravenous injection produced urticaria, rhinitis and conjunctivitis, subsequent subcutaneous injections were given without untoward results.

In four patients fever has occurred during heparin treatment and abruptly disappeared following discontinuance of the drug. This fever did not recur when one or two subsequent injections were given these individuals. It was our impression that the febrile reaction was directly related to the heparin administration as has been previously reported by Jorpes<sup>15</sup>.

While heparin possesses the favorable properties of immediate effect and short duration of action, it possesses two disadvantages, namely the necessity of parenteral administration and the expense. The daily cost of heparin for a patient ranges between five and seven dollars.

Although previously in some groups<sup>10</sup> a critical instance

bolism) we have advised immediate heparinization as the usual program in view of the uncertainty of predicting which individuals will experience embolic phenomena. In this way it is possible to produce immediately the desired antithrombotic effect as well as to diminish the total duration of therapy for the patient.

**Dicumarol** \*Except for the few patients to whom only heparin was given, dicumarol was the principal anticoagulant started on the first day and continued throughout the entire period of treatment. Dicumarol has the advantage of being effective when administered orally.

\* A portion of the dicumarol used in this study was supplied by the courtesy of E. R. Squibb & Sons, New York, N. Y.

in one dose daily and of being remarkably inexpensive. There is a lag period, usually twenty four to forty eight hours after the administration of dicumarol, before its effect is apparent. It should thus be borne in mind that in ordering dicumarol the dosage should be gauged for twenty four to thirty six hours in advance. There is a potential disadvantage in the fact that return of the prothrombin activity to normal is delayed for one to seven days when dicumarol is discontinued.

Inasmuch as the effect of dicumarol on the venous blood clotting time is irregular and inconstant,<sup>16,17</sup> the daily dose of dicumarol is guided by a prothrombin time determination performed each day. The one stage Quick prothrombin time method<sup>18</sup> has been performed on whole plasma according to the Link Shapiro modification.<sup>19</sup> At the

the dilute prothrombin time did not contribute sufficiently to the safety of administration of dicumarol to compensate for the extra labor and cost entailed. Normal values in this laboratory for this technic are 14.6 ( $\pm 2.3$ ) seconds. The per cent of prothrombin activity has been determined by the saline dilution method and the logarithmic prothrombin activity curve of Quick.<sup>20</sup> Critical values by this method in our laboratory are as follows: 100 per cent of normal prothrombin activity is 14 seconds, 30 per cent is 22 seconds, 20 per cent is 32 seconds, and 10 per cent is 45 seconds. In our experience as well as others, the constancy of the thromboplastin employed is the most important key to reliable prothrombin time determinations. A commercially supplied rabbit lung thromboplastin has proved to be satisfactory in our hands, each new lot being checked against a known standard. As an added precaution the prothrombin time of a normal individual is determined each day along with the dicumarol treatment blood samples.

After having ob

but safe  
(30 per  
cent of normal activity) and 45 seconds (10 per cent of normal activity).<sup>21</sup> Subsequent daily maintenance doses are determined according

to twenty four hours whenever the prothrombin time is less than the critical antithrombosing level of 22 seconds

It has been reported,<sup>4</sup> and it has been our experience also, that between 10 and 20 per cent of individuals overreact to the usual dose of dicumarol. In these patients significantly lower dosage was necessary,

disease, and individuals receiving drugs which produce intestinal bacteriostasis

Excessive hypoprothrombinemia was treated promptly with parenteral synthetic vitamin K (menadione bisulfite) in doses of 25 to 100 mg, the amount of vitamin K depending on the elevation of the prothrombin time. In most patients 72 mg of menadione bisulfite resulted in a reduction in prothrombin time to safe range (below 45 seconds) within twelve to forty eight hours. If no effect was apparent at twenty four hours, the dose of menadione was repeated. In only two cases has there been observed a subsequent uprising of prothrombin time after the downward trend had started. Although we have administered vitamin K in massive dosage to a sizable number of individuals with excessive hypoprothrombinemia, we have not observed a single instance in which it appeared that vitamin K produced a hyperprothrombinemic state or precipitated further intravascular clotting.

Bleeding during and presumably due to dicumarol administration has been encountered in approximately 6 per cent (thirteen patients) of this group but has been of severe degree in less than 1 per cent. No deaths due to the uncontrolled bleeding occurred in this series. We have observed no cases in whom the severity of hemoptysis appeared to have been intensified by anticoagulants and no instances in which hemorrhagic pleural effusion occurred which was not attributable to the usual postinfarction process.

When significant hemorrhage occurred, in addition to vitamin K therapy as outlined above, either fresh whole blood or plasma has been recommended<sup>3, 10</sup> as an immediate but temporary means of returning the prothrombin time to the safe range. Observations in this laboratory<sup>11</sup> have confirmed Strumia's original report<sup>20</sup> that lyophilized plasma reconstituted with 0.1 per cent citric acid possesses a normal prothrombin content comparable to that of fresh whole blood. Despite the 45 per cent incidence<sup>3</sup> of homologous serum hepatitis following the use of lyophilized plasma — difficulties would certainly indicate hemorrhagic emergencies due to dicumarol, particularly by physicians

in one dose daily and of being remarkably inexpensive. There is a lag period, usually twenty-four to forty-eight hours after the administration of dicumarol, before its effect is apparent. It should thus be borne in mind that in ordering dicumarol the dosage should be gauged for twenty-four to thirty-six hours in advance. There is a potential disadvantage in the fact that return of the prothrombin activity to normal is delayed for one to seven days when dicumarol is discontinued.

Inasmuch as the effect of dicumarol on the venous blood clotting time is irregular and inconstant,<sup>16,17</sup> the daily dose of dicumarol is guided by a prothrombin time determination performed each day. The one-stage Quick prothrombin time method<sup>18</sup> has been performed on whole plasma according to the Link-Shapiro modification.<sup>19</sup> At the start of our program both the whole and dilute (12.5 per cent) plasma prothrombin times were followed in estimating dicumarol dose. However, it was concluded, after a six-month period of evaluation, that the dilute prothrombin time did not contribute sufficiently to the safety of administration of dicumarol to compensate for the extra labor and cost entailed. Normal values in this laboratory for this technic are 14.6 ( $\pm 2.3$ ) seconds. The per cent of prothrombin activity has been determined by the saline dilution method and the logarithmic prothrombin activity curve of Quick.<sup>20</sup> Critical values by this method in our laboratory are as follows: 100 per cent of normal prothrombin activity is 14 seconds, 30 per cent is 22 seconds, 20 per cent is 32 seconds, and 10 per cent is 45 seconds. In our experience as well as others, the constancy of the thromboplastin employed is the most important key to reliable prothrombin time determinations. A commercially supplied rabbit lung thromboplastin has proved to be satisfactory in our hands, each new lot being checked against a known standard. As an added precaution the prothrombin time of a normal individual is determined each day along with the dicumarol treatment blood samples.

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catheters and open granulating wounds without untoward experience with bleeding.

**General Management.**—All patients with the diagnosis of deep venous thrombosis or pulmonary embolism were placed at complete bed rest, usually with legs elevated, and carefully instructed to avoid all exertion and straining. Anticoagulants were immediately begun, usually with both heparin and dicumarol. This program was maintained until six days had elapsed. If by that time the clinical picture was satisfactory, both as regards the general condition of the patient and the status of the phlebitis or lung infarct, the patient was allowed up and encouraged to walk rather than sit in a chair. Elastic bandages or stockings were advised for the first week of ambulation and thereafter as indicated by subjective or objective postphlebitic complaints. Anticoagulant therapy was continued until the patient was completely ambulatory, usually a minimum of four to six days after starting out of bed, and then anticoagulants were canceled. The entire course of treatment usually took two weeks. We have observed no rebounds of the prothrombin time below  $14 (\pm 2)$  seconds (hyperprothrombinemia) following the cessation of dicumarol. The usual pattern is a gradual return of the prothrombin time to normal predicumaryl levels over a period of two to seven days.

In patients in whom embolism of severe degree has occurred, atropine and papaverine have been administered in an attempt to counteract noxious effects of bronchial and arterial reflex spasm associated with severe embolism.<sup>27</sup> Penicillin has been given prophylactically to avoid secondary infection in the infarcted area of the lung. Patients in whom overt cardiac failure is present or with a markedly decreased reserve have been digitalized. Neither penicillin nor digitalis has been conclusively demonstrated to be a clinically significant thrombolytic agent.<sup>28</sup> Intercostal nerve block with procaine has been successful in several patients in relieving otherwise intractable pleuritic pain. The placing of an acutely ill patient in oxygen has been observed consistently to make them more comfortable even though the major portion of the respiratory difficulty has been due to pleuritic pain.

## RESULTS

**Venous Thrombosis.**—Ninety-six patients presenting the clinical picture of acute deep venous thrombosis of the lower extremities have been treated with the anticoagulant program as outlined. With the exception of six patients treated with heparin alone and two with dicumarol alone, all cases received dicumarol with concurrent heparinization during the first one to three days of the treatment period. Subsequent to starting therapy, three patients experienced small non-fatal pulmonary emboli. All these emboli occurred prior to the sixth



not located in proximity to established blood banks. In our hands 500 cc of lyophilized plasma has been effective in producing an immediate reduction of the prothrombin time to safe range when administered to patients with excessive hypoprothrombinemia. This reduction was maintained for as short a period as six hours thus necessitating multiple transfusions in certain instances in order to keep the prothrombin time in this presumably safe range until the menadiol effect was attained.

If the hemorrhage was of such magnitude that additional anticoagulant therapy was deemed inadvisable, a decision was made at the time of the operation as to the period of adequate anticoagulant effect had been too short, ligation of the peripheral

rol, we have encountered nausea and vomiting considered to be due to the drug in about 2 per cent, increased peristalsis and diarrhea in about 2 per cent and headache in a like number.

As have other investigators<sup>4, 10, 21</sup> we have administered dicumarol and heparin to women in the immediate postpartum period. Each drug has been given as early as the first day following delivery. A group of

patients both but red

Despite the experimental study<sup>1</sup> that excessive dicumarol leads to

this series have received heparin and dicumarol without any effects in their nursing babies.

Dicumarol as well as heparin should be avoided in patients with recent or current gastrointestinal bleeding, those with a central nervous system operation within one week, in women with threatened abortion who desire a viable fetus and in subacute bacterial endocarditis except when embolic peripheral arterial occlusion or pulmonary embolism secondary to peripheral deep venous thrombosis has occurred. In women within a month of estimated date of delivery heparin is thought to be preferable due to its shorter duration of action and easy ability to be counteracted should labor unexpectedly start. We have cautiously administered both heparin and dicumarol to patients with T tube biliary drains, Miller Abbott tubes indwelling

ulability of the blood in thrombotic situations, it is obvious that the one of the most pressing needs in the thromboembolic problem is for an accurate test to indicate when the process of intravascular clotting has completely subsided

**Pulmonary Embolism.**—One hundred and seven patients who had already experienced one or more definite or clinically presumptive pulmonary emboli have been managed by this program. In this group there were three patients (2.8 per cent) who experienced additional small nonfatal pulmonary emboli after the start of treatment. All subsequent emboli occurred prior to the sixth day of adequate anticoagulant therapy, one occurring in a patient who was mistakenly ambulated three days after starting anticoagulants. No emboli occurred after therapy had been completed. There has been one death (0.9 per cent) due to massive pulmonary embolism (confirmed at autopsy) subsequent to the start of therapy. The fatality occurred ten minutes after the usual initial dose of heparin. In this group of one hundred and seven patients there was only a 2.8 per cent incidence (three patients) of recurrent phlebitis. This lower incidence in the embolic group is compatible with the current concept that those venous thromboses which produce pulmonary emboli are usually less inflammatory and more bland in nature and thus less likely to recur.

Approximately one half of these one hundred and seven patients presented no evidence of deep venous thrombosis at the time these patients were seen initially because of pulmonary embolism. In some of these persons symptoms or signs later developed indicating a thrombotic process in one extremity. This was additional confirmation of the diagnosis of thromboembolism in these patients. Such occurrences only served to emphasize that, although the presence of venous thrombosis in a patient suspected of pulmonary embolism is extremely weighty evidence, the absence of clinical deep venous thrombosis at the time of embolism should in no way militate against the diagnosis.

**Prophylactic Anticoagulant Therapy.**—Although it is not possible to consistently detect the thrombophilic individual by a simple laboratory test, the prophylactic use of anticoagulant therapy has sharply reduced the occurrence of thromboembolism in the postoperative, individuals ill with pointed to the fact greater incidence of

thrombotic disease than expected<sup>28</sup>

Fifty-one patients in this series have received dicumarol prophylaxis for various indications as shown in Table 2. In this group, approximately one half were treated because of a history of previous thromboembolism. There were no fatal or nonfatal pulmonary emboli in this group. Only one patient (1.9 per cent) suffered a venous thrombosis and in this patient the anticoagulant effect had not been adequately

day of *adequate* anticoagulant effect one following almost immediately after manipulation of the patient during the administration of a paravertebral lumbar sympathetic block. No fatal emboli occurred in any patient of this group.

TABLE 1

RESULTS OF ANTICOAGULANT THERAPY IN 254 PATIENTS

Type of Case	Number of Cases	Subsequent Venous Thrombosis	Subsequent Nonfatal Pulmonary Embolism	Subsequent Fatal Pulmonary Embolism
Venous thrombosis	96	7(7.3%)	3(3.1%)	0
Pulmonary embolism	107	3(2.8%)	3(2.8%)	1(0.9%)*
Prophylactic	51	1(1.9%)	0	0

\* This fatality occurred from a massive pulmonary embolism ten minutes after the start of heparin therapy.

Embolization has been encountered in three of the ten cases of acute thrombophlebitis of the deep veins. These three cases have served to strengthen our original premise that even the acute inflammatory deep venous thromboses (thrombophlebitis) should receive anticoagulant treatment as well as symptomatic measures such as sympathetic block because of the possibility of dangerous bland thrombus material either proximal to the inflammatory thrombosis or in the contralateral deep venous system.

There were seven patients (7.3 per cent) in whom recurrent venous phlebotrombosis. In these patients the initial pain and tenderness seemed to remain longer than in the usual patient. In retrospect we believe that any patient with an inflammatory deep thrombophlebitis whose pain and tenderness persist beyond the first seven to ten days

group after a two to four month follow up period. It may be that some of the individuals of this group may need an even longer period of treatment (i.e. up to two or three months) but this can be determined only by experience. Although certain modifications of blood coagulation tests have been reported<sup>28</sup> to show accelerated coag

Ninety milligrams of papaverine intravenously was followed by complete relief of all vasospasm and symptoms within fifteen minutes. It is our belief that papaverine should at least receive a trial in cases presenting this type of a problem.

The pharmacological block of autonomic ganglia has been made possible by the introduction of tetraethylammonium chloride. The most recent report<sup>34</sup> from the Michigan group included twenty six patients who were treated because of thrombophlebitis. This agent produced striking permanent results in four cases of acute or subacute thrombophlebitis. Twenty-one cases of a more chronic phlebitis with edema, pain, either temporary or permanent, and recurrent symptoms of upper extremities.

recurred. Subsequent injection of this agent again produced marked relief. It would appear that this is an extremely useful drug. Maintenance doses of which may well enable a patient with chronic phlebitis to be free of troublesome discomfort and edema indefinitely.

Tetraethylammonium chloride\* has been administered to seven patients of this series. One man with a 6 months old iliofemoral thrombosis received no relief from six twice weekly doses of 300 mg. as regards swelling, edema or subjective heaviness. One woman with persistent femoral vein tenderness of three weeks duration obtained no relief after two 250 mg. injections. Three patients with chronic iliofemoral block manifested by swelling, cyanosis and discomfort or pain (particularly towards evening) were temporarily relieved for varying periods of time and subsequent return of symptoms was again successfully managed by tetraethylammonium chloride. Two patients with an acute iliofemoral thrombosis experienced rapid clearing of the major portion of their edema and discomfort.

In our experience, further evaluation is indicated from these encouraging results.

**Surgical Treatment.**—Bilateral ligation of the superficial femoral vein has been carried out during this period in ten patients. In this group anticoagulants were either contraindicated or severe bleeding had already occurred while receiving anticoagulants. Four of these patients had preoperative prophylactic ligation because of a history of previous deep thrombosis. In one of these a nonfatal pulmonary embolus occurred four days following ligation (two days after a common duct exploration). The patient was subsequently treated with dicumarol and heparin and her course was uneventful. In patients who are treated by ligation it would appear sound also to administer anticoagulants following ligation unless these drugs are contraindicated. This program aims at preventing proximal thrombosis at the site

\*The tetraethylammonium chloride was supplied by courtesy of the Parke Davis and Company, Detroit, Michigan.

maintained. The optimal duration of prophylactic anticoagulant therapy has been difficult to determine. In general the principle has been followed that the therapy should be continued until discharge or until the patient is fully ambulated at about two weeks after operation. Attempts have been made to avoid extension of hospital stay for the sole reason of administering prophylactic anticoagulants.

TABLE 2

INDICATIONS FOR PROPHYLACTIC ANTICOAGULANT THERAPY IN FIFTY-ONE CASES

<i>Clinical Indication</i>	<i>Number</i>
History of previous thromboembolism	25
Advanced senility	5
Extensive varicosities	5
Malignancy of large bowel	4
Abdominoperineal resection	4
Extreme obesity	3
Platelet count in excess of 1 000 000	2
Amputation of lower extremity	2
Hysterectomy	1
Total	51

It is fully agreed that universal use of prophylactic anticoagulants is impractical. However, their employment in a selected group (such as those listed in Table 2) appears to be logical and valuable. It is becoming more apparent from recent reports<sup>29, 32, 33</sup> that early or accelerated ambulation may not have eliminated or even substantially reduced the occurrence of thromboembolic episodes as was anticipated from earlier reports. Thus there is a need for specific prophylactic measures such as anticoagulants or venous ligation.

**Management of Vasospasm**—Paravertebral lumbar sympathetic nerve blocks with 1 per cent procaine solution have been administered to fifteen patients who have shown marked edema, severe pain or vasospasm. It is our experience that the inflammatory phlebitis characterized by vasospasm, prolonged severe pain or edema is much less frequent than anticipated. However, when employed for these indications paravertebral block has been successful. One treatment has produced satisfactory results in most cases and repeated blocks were needed in only three patients. In one patient with a bilateral inflammatory phlebitis, caudal anesthesia was particularly effective in producing bilateral improvement.

Papaverine hydrochloride (in doses of 90 mg parenterally as frequently as every four hours) has produced improvement in pain and tenderness in about one half of a small group of patients. In one elderly woman a marked vasospasm with severe pain and obliteration of all arterial pulsations in the left lower extremity occurred on the fourth day of a deep venous thrombosis of the calf and popliteal vein.

transfusion of whole blood, whole plasma, or lyophilized plasma was given 30 minutes before the start of the operation. Transfusion was repeated at six hour intervals for approximately twenty-four to thirty-six hours.

Four operations have been performed under this program without

experience has been treatment in whom surgical procedures have been carried out without any therapy aimed at counteracting significant hypoprothrombinemia. These patients underwent surgery without undue bleeding occurring in any case despite prothrombin time determination ranging between 22 and 60 seconds. This series included two cholecystectomies, three amputations of lower extremities, five extractions of one or more teeth, two incisions and drainages of purulent foci, one exploration of the frontal ethmoid-sphenoid sinus area, one excision of a sebaceous cyst and one biopsy

up the unusual state of altered coagulability produced by anticoagulants, which prevents pathological clotting of intravascular nature but which does not inhibit normal hemostasis in extravascular clotting. Further evaluation of this observation is being cautiously continued.

It may be noted that, in individuals who were receiving anticoagulants prior to an operation, there usually exists some reason (pulmonary embolus, venous thrombosis, or cardiac infarction) for continuing anticoagulants in the postoperative period—prophylactically, if not therapeutically. Therefore, dicumarol with or without heparin as indicated has been restarted at approximately twenty-four to forty-eight hours postoperatively.

**Ambulatory Anticoagulant Therapy.**—Ambulatory dicumarol administration has been conducted successfully by us, as well as by

at various times have caused us to follow the prothrombin time more closely. Our program of ambulatory dicumarol entails checking the prothrombin time twice weekly in all patients under our care. Ten patients have been treated by this routine for periods of one to four months (individuals with auricular fibrillation and embolic phenomena of intracardiac origin have been treated for the four months period) without any bleeding complications. Dicumarol obviously has many

of ligation<sup>34</sup> as well as at avoiding propagation of thrombus material in the pulmonary artery<sup>3</sup> when embolization has already occurred. Ligation of the common iliac vein or vena cava interruption has been reserved as last resorts for those patients in whom repeated embolism has occurred despite peripheral vein ligation and/or adequate anti-coagulant therapy. These two operations have not been performed in this series.

**Postthrombotic Sequelae.**—The absence of postphlebotic symptoms have been striking in this anticoagulant treated group. Those patients in whom pulmonary emboli occurred from undetermined sources were universally without subjective or objective postthrom-

had the popliteal vein already involved initially, many swellings were present in about half the patients at the start of mobilization but

## GENERAL CONSIDERATIONS

**Operative Procedures in Patients Receiving Anticoagulant Therapy.**—In the natural course of medical events, surgical intervention for acute surgical emergencies may arise in patients receiving

1. If operation is required within 24 hours, 72 mg of menadione bisulfite was administered intravenously repeated in eight to twelve hours if so indicated by the prothrombin time. Operation was performed when the prothrombin time had returned to normal.

2. If immediate operation was mandatory, 72 mg of menadione bisulfite was administered parenterally. Inasmuch as a substantial lag period existed before the desired effect of menadione was manifest

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## SURGICAL MANAGEMENT OF VENOUS CLOTTING

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THE pendulum oscillates in surgery and it is not unusual for one to see an entirely different treatment advocated for the same lesion within a few years. Thus gastroenterostomy for peptic ulcer has dis-

a condition as we hear at the meetings and see in the reports in the literature on the management of venous clotting. It is possible that sufficient time and experience with various methods of treatment has not elapsed to crystallize the correct procedure and it may take an analysis of the experiences of another ten years to show us the correct path. It is more likely, however, that we now know the right therapeutic route, and our difficulty results from our inability to select the right method for the individual patient. If this is true for those who see these patients by the hundreds, the problem for the surgeon with the occasional case must be extremely confusing.

The experience of a large clinic can be helpful provided the report is expressed without prematurely claiming one method is the only one to employ prior to the time that it has been proved so to everyone's satisfaction. Anxiety to be original causes many to publish too early reports not substantiated by controls or follow up reports. Worse than this is the failure to correct published reports on methods which the originator has found necessary to discard. An example is the present widespread use of ligation of the inferior vena cava for clotting whereas many of the early advocates rarely employ it now. It takes about two years for the profession to take up a surgical method after it has been published. Specialists owe it to the profession to review their old reports and correct them when necessary. We will endeavor to do this at this time.

### THE PROBLEM OF VENOUS CLOTTING

Clotting has been studied for many years, and the improved laboratory methods have not greatly changed the conception of such early physiologists as Howell and Aschoff. From the practical and

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hundred and two patients requiring femoral resection were over 40 years of age (Allen Linton and Donaldson) In a review which I have just completed of ninety massive pulmonary embolisms at the New York Post Graduate Hospital in which there were seventy four deaths the largest single group (30 per cent) occurred in those

TABLE 1

INCIDENCE OF MAJOR PULMONARY EMBOLISM ON THE VARIOUS SERVICES OF A GENERAL HOSPITAL (NINETY CASES)

	Total Number	Fatal
General Surgery	39 (43%)	30 ( 82%)
Gynecology	13 (15%)	11 ( 84%)
Genitourinary	13 (15%)	9 ( 69%)
Eye	1 ( 1%)	1 (100)%
Bronchoscopy	1 ( 1%)	1 (100%)
Vascular Surgery	7 ( 8%)	1 ( 14%)
Orthopedic	2 ( 2%)	2 (100%)
Plastic	1 ( 1%)	1 (100%)
Medical Service	13 (15%)	10 ( 78%)

between 60 and 70 years of age and 47 per cent occurred in patients between 40 and 60 years of age Thus nearly 80 per cent of these pulmonary embolisms occurred in patients over 40 years of age This is in line with the 83 per cent reported by Stich Part of this higher incidence with increasing age may be due to less ambulation and/or cardiovascular renal changes

TABLE 2

INCIDENCE OF MASSIVE PULMONARY EMBOLISM ON THE GENERAL SURGICAL SERVICE (THIRTY-NINE CASES)

	Total Number	Fatal
Gastric Surgery	13 (33%)	11 ( 84%)
Gallbladder	7 (19%)	5 ( 71%)
Appendectomy	5 (13%)	4 ( 80%)
Breast	4 (11%)	4 (100%)
Hernia	3 ( 8%)	3 (100%)
Colon	3 ( 8%)	3 (100%)
Exploratory Operation	4 (10%)	2 ( 50%)

Table 1 shows the incidence on the various services of the hospital and illustrates that any and all types of patients are susceptible to embolism The extremely high mortality rate is well shown Table 2 is a breakdown of thirty nine cases on the general surgical service The incidence even after breast amputation emphasizes the part that bed rest plays in venous clotting

clinical standpoint, we may summarize these ideas and say that clotting occurs when three conditions are present, as follows

1 *Some change in the intravascular clotting factor* This may be due to a change in the prothrombin, fibrinogen, or calcium content. There is fair evidence that high platelet counts increase thrombosis. This clotting change, if not interrupted, will continue to a fibrosis. In the absence of inflammation this clot may be bland and mobile. It may propagate or move in the vein.

2 *Stasis* It has been adequately proved that slowing of the blood in the vessel is of prime importance, both in the production of the

this intravascular clotting factor. That this is true is shown by a large number of clots appearing in the leg vessels of patients who merely are put at bed rest. This stasis interferes with the muscular pumping action on the veins, such as occurs when a patient is walking, and which aids in their regular emptying. Stasis also results often in an endothelial irritation or injury.

3 *Tissue Injury* The part the tissue injury plays in clotting was recognized by the early physiologists. At first it was believed necessary that the injury be an external one, with the release of tissue juices. It is now recognized that this injury may be relatively minor, internal or indirect, and may be due to the rubbing of the two endothelial walls of the veins together over a period of time, this may be caused by the pressure of a bed on the calves of the legs, or by a tight band or tourniquet.

That other factors may be important is recognized. *Polycythemia* or a condition such as *hemorrhage*, which increases the viscosity of the blood, may be a factor. *Anemia* may cause clotting by its relative increase in the cellular elements as pointed out by Drinker and Kreutzmann or by the reduced cardiac activity and secondary stasis. *Hypoproteinemia* with *hyperglobulinemia* causing an increased sedimentation rate may be a factor, as suggested by Sulger. The change in the *agglutinability* of the thrombocytes may cause clumping and initiate a thrombus (Wright and Ochsner). The change in the electrolytic power causing this is related to the *albumin globulin* ratio and occurs when this ratio is reversed. How much the use of tobacco

plays a part in thrombosis and usual Eighty-one per cent of two

which the clot is early accompanied by inflammation. By thus eliminating such terms as thrombophlebitis, phlebothrombosis, periphlebitis, silent, quiet and bland thrombosis, we try to make the picture clearer. That the two conditions are confused by many is shown by the number of consultations received where femoral, iliac or vena cavaligations are suggested or performed for a red streak and some swelling i.e. thrombitis in the leg. Much of this confusion results from the nomenclature.

### SYMPTOMS

**Thrombitis**—All of us are aware of the symptoms of thrombitis and they merely need to be mentioned. These are the signs of inflammation and consist of redness, usually streaky, swelling, pain, and tenderness along the vein. Chills and fever may occur and leukocytosis and increased sedimentation rate are usual. Suppuration is an occasional complication. Embolism in the thrombitis patient may occur but it is usually small as the inflammation causes adhesion of the clot to the vein wall. Seven of our last four hundred and eighty patients with thrombitis developed pulmonary embolism, all of a minor type (Table 3).

TABLE 3

DIAGNOSIS OF VENOUS CLOTTING: SYMPTOMS OF THROMBITIS (INFLAMMATION)  
(In order of frequency)

- 1 Pain at site and along vein
- 2 Redness along involved vein
- 3 Swelling distal to inflammation
- 4 Tenderness along vein
- 5 Fever and temperature
- 6 Chills
- 7 Leukocytosis

**Thrombosis**—The symptoms in thrombosis are not as well differentiated or understood. We believe the diagnosis can be made early if the condition is kept in mind. In an effort to bring out the more important symptoms, we have outlined them in the order of their importance in the ninety reviewed massive embolisms (Table 4). Pain

TABLE 4

DIAGNOSIS OF VENOUS CLOTTING: SYMPTOMS OF THROMBOSIS (NO INFLAMMATION)  
(In order of frequency)

- 1 Pain (usually popliteal space or calf)
- 2 Tenderness (same area)
- 3 Mild swelling
- 4 Dilatation of veins over tibia
- 5 Cyanosis
- 6 Increased pulse and temperature
- 7 Sense of impending disaster
- 8 Hypotension
- 9 Embolism

**Cardiovascular Diseases**—Of our ninety massive embolisms, forty six, or slightly over 50 per cent, had cardiovascular disease, and its connection with thrombosis cannot be denied. Burke reported over 60 per cent of his patients had cardiac disease, and Phib, Ophuls and Dobson found 52 per cent of their embolism patients had cardiovascular disease. Farkas and Putnoky's series of ninety-one embolisms showed that 90 per cent had cardiovascular disease.

**Previous Thrombosis**—Previous thrombosis or phlebitis, while worthy of note, does not seem to be too great a factor. Only 9 or 10 per cent of our patients with massive embolisms had any history or findings suggestive of previous venous trouble. Burke's report of two hundred and eighteen patients who developed postoperative clots on a second operation, after having no such complication on the first operation, likewise substantiates this thought.

**Obesity**—Obesity is a definite predisposing factor. Henderson,

cases as carcinoma have an increased tendency to thrombosis is well established and may be due to the increased cellular content of the blood stream. Twenty six per cent of our massive pulmonary embolisms followed operations for carcinoma. Trosseau pointed out that venous clotting may be an early sign of carcinoma, and we have seen and observed it. In the last year, we have performed total hysterectomy five times for carcinoma of the fundus of the uterus in patients sent to us only for venous complications. Carcinoma of the body or tail of the pancreas results in more thrombi than carcinoma of the head of the pancreas, according to Sproul and Kenny. In our series no carcinomas of the pancreas were listed.

**Fungus Infection**—Fungus infection may play a part and will be discussed with treatment.

**Types of Venous Clotting**—There is no longer doubt that there are two types of venous clotting of clinical importance. Ochsner, DeBakey, Allen, Linton and others have written voluminously on these points, and they draw a definite pathological difference between the two. We do not believe that there is a great deal of difference, either in etiology or pathogenesis. The important point is whether or not inflammation accompanies the clot. That inflammation occurs in all clotting if the condition continues long enough regardless of the type seems certain. In its symptoms, later pathology and prognosis however, there is a definite difference. To avoid confusion in terms we call the two conditions *thrombosis* and *thrombitis*, defining thrombosis as a condition in which clotting is the primary factor and the inflammation minimal or secondary, and thrombitis as a condition in

tinued in all patients who are to be in bed at all, and especially if they are to have a major operation

The world seems to be infected with *fungus infection* permanently. One observer's statement that 50 per cent of all people have it and 50 per cent have just recovered from it is nearly true. Unless one never goes to a beach or bath he may have it. With this infection there are skin breaks and a point of entrance for infection. Many of us believe through the blood stream.

SOAKS (10000 or 115000) twenty minutes every other day. Irritating drugs and caustic fungicides are contraindicated as is x ray therapy.

The elimination of anemia, the avoidance of chilling and, most important of all, continued ambulation of the patient up to the operation time and immediately thereafter will strikingly reduce the instance of postoperative thrombosis. A program of this type was inaugurated on our surgical service at the U. S. Naval Hospital at Saint Albans, L. I. In the last year of the war 5100 of the 6600 operations performed were major procedures which usually were followed by bed rest. In these operations with few exceptions the patient was out of bed as soon as the anesthetic effect was eliminated. How rare were these exceptions is shown by the fact that the average bed days after operations for recurrent hemia was 2.4. We were able to start this early movement by using buried steel wire sutures in the fascia. Local anesthesia for all operations.

anesthesia

instance

While it

It is a fact that these were relatively young individuals, veterans also were being treated as were many elderly officers and chiefs, illustrated by the fifty five gastric resections we performed. Where ambulation is impossible we passively move the extremities of the patient and then stimulate early movement. We tell our patients to move their legs three thousand times. The more one considers the problem the more important *bed rest* becomes in the production of these lesions, both from the stasis and the trauma standpoint. Prophylactically in the group with an old inflammatory history the veins may need to be resected. Anticoagulants have a place in their treatment. Elimination of the phlebotic patient from the elective operation list may be a wise measure for at least a year after the attacks. Ambulation in the inflammatory group is extremely important. When active inflammation is present, therapy changes as will be discussed.

## ACTIVE TREATMENT





ligation of her superficial femoral vein. It was apparent that clotting had occurred above the ligation site. The vena cava resection was followed by no further embolism. The vein should be opened, ligated, transfixed and divided. Of two hundred and seventy nine major vein resections in the last year, sixty one or 21 per cent have been common femoral vein sections. In contrast to twenty six vena cava ligations two years ago only two were performed this last year. For thrombosis where vein section was considered imperative, the operation was done bilaterally in only 6 per cent.

**Anticoagulants**—We do not believe that operation and anticoagulants should be considered separately. We use anticoagulants in instances whether we operate or not. The program we follow is based on the prothrombin level. Four hundred mm of dicumarol is given by mouth at once. One hundred to 200 mm is given on the following day; the dosage thereafter is based entirely on the prothrombin level. We try to keep this level between two and three times the normal (which is 14 to 16 undiluted, 36 to 45 in a 12.5 per cent dilution) as has been pointed out by Wright and Duryee. In the serious case heparin can be given until the dicumarol effect is apparent. The introduction of heparin by a catheter inserted into a vein through a needle after which the needle is withdrawn makes the heparin injection more readily controlled. We believe the menstruum of Pitkin as advocated by Loewe has no advantage over the intravenous method. It is painful and subjects the patient to many unnecessary reactions.

**Ambulation**—The patient should be kept up after the operation. Many times if an embolus occurs when the patient is up the movement is blamed for the embolus. We believe it occurs in spite of the movement as we have seen many emboli without ambulation some while the patient emphasize to the exists and that w

should it occur it is in spite of rather than because of the ambulation.

**Thrombosis**—The part that reflex spasm plays in this picture has been amply emphasized and demonstrated by LeRiche, Ochsner and DeBakey. It is apparent that spasm is the cause of much of the pain, edema and continuation of the process. That this is on a reflex sympathetic basis is certain. If this reflex is interrupted and the best place to interrupt it is at the ganglia the cycle is broken, spasm ceases and may not reactivate itself. Sympathetic nerve blocks, therefore, are indicated and in our hands good results follow in over 75 per cent. More than one block may be required. Anticoagulants have their place in this therapy and should be used. The leg should be kept mobile and while bed rest during the acute inflammatory part of the process may be helpful motion should be kept up. Chemotherapy in the form of penicillin has been used empirically and should be continued until

feeling now is that there are very definite indications for a ligation and some questionable ones (Table 5)

TABLE 5

SURGICAL MANAGEMENT OF THROMBOSIS (INFLAMMATION ABSENT OR MINIMAL)

- 1 Vein resection
  - (a) If early diagnosis
  - (b) If anticoagulant therapy is ineffective
  - (c) If embolism occurs
  - (d) Previous history of clotting
  - (e) Fear
- 2 Ambulation
- 3 Anticoagulant therapy
  - Dicumarol
  - Heparin early
  - (Contraindicated in some cases, e.g., peptic ulcer)
- 4 Thrombectomy
  - If clot is higher than ligation point

1 If the patient has survived an embolus, and is untreated, he has a 50 per cent chance of another one, and between a 25 and 30 per cent chance that it will be fatal. We believe this is an absolute indication to resect the vein proximal to the clot. If one cannot resect proximally, thrombectomy is possible.

2 If the patient has not responded to anticoagulant therapy, as

an indication to resect the vein.

4 We may resect the vein if the patient fears an embolus to such an extent that he is incapacitated. Many of these patients know when an embolus will occur, and it is an important sign.

*Vein Resection*—When it is decided to resect a vein, we believe the resection should be carried out in the femoral area unless there is evidence of a bilateral involvement, indicating that there is clotting above this point. When a thrombus is in the groin, we resect the common femoral vein—that is, proximal to the saphenous and the femoral profunda. We open the vein with the patient in the Fowler

prevent the majority of the emboli. Where there is evidence of bilateral involvement, the operation can be performed on both sides or, in rare instances, at the vena cava. An illustration of such a rare instance is that of a doctor's wife who had an embolism after the

found directly in the superficial femoral vein in the groin, again showing the valve failure. In the last two years we have resected thirty-six superficial femoral veins with ulcers with healing of the ulcer in thirty-two instances. In some ulcers, of course, other measures such as skin grafting and sympathectomy have to be added to the procedure, but these same measures when added without the superficial femoral vein resection failed.

**Dilated Veins**—Enlarged superficial veins will follow resection as collateral circulation develops. After a period of a year or two, they may require resection again. This is not the development of a new complication but rather the necessary collateral circulation. The interruption of these collateral veins too early may cause very serious complications in the venous return. By the end of the year, when the ulcer has developed, the saphenous system likewise is usually inadequate and its resection at the femoral junction and at the incompetent points can be done at the same time.

**COMMENT**

We are presenting our thoughts as they are today, and already some  
 the program as out  
 year there will be  
 with progress that

30 East 60th Street New York City

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one is certain there is no bacterial focus. The hot pack is of value in relieving pain and edema. It probably functions by relaxing the collateral passages. These packs should be ordered carefully, as a burn may be a serious complication. The skin should be protected by lanolin.

Heat is also helpful (Table 6)

TABLE 6

## SURGICAL MANAGEMENT OF THROMBOSIS (INFLAMMATION PRESENT)

- 1 Paravertebral sympathetic nerve block
- 2 Anticoagulant therapy  
Dicumarol  
More rarely heparin
- 3 Mobility of the patient  
Active and passive motion
- 4 Heat  
Warm packs or reflex heat
- 5 Sympathectomy occasionally

## COMPLICATIONS

**Edema.**—While our early common femoral ligations were followed by edema in 40 per cent, good support and elevation has reduced this to 2 per cent in the last one hundred cases. We believe edema will occur after such procedures if the superficial vessels are clotted, thus preventing collateral venous return. If marked edema occurs, the patient probably had thrombosis, not thrombosis, and did not require ligation.

**Ulcer.**—Ulceration occurs approximately one year after the acute phlebitis. This appears to occur, as Linton explains, at the time of recanalization of the superficial femoral vein. In these cases with a valve failure and the inability of this vein to recanalize, back pressure and stasis in the superficial femoral system occurs similar to that in the deep system when the competent femoral valve fails. Resec-

At first, before resecting these femoral veins, we tested the patient to determine the femoral valve competency. If one puts a Babcock type stripper into a normal superficial femoral vein, he will find he cannot advance it more than a few inches because of the valves. In the postphlebotic femoral vein, the stripper strikes no valves, its progress being stopped only if there is fibrosis. In some patients a stripper placed in a large feeding vein directly above an ulcer will be

## THE SURGERY OF CONGENITAL HEART DISEASE

GEORGE H. HUMPHREYS II M.D., F.A.C.S.\*

IN the decade which has passed since it was first demonstrated that a persistent patency of the ductus arteriosus could be accurately diagnosed and successfully closed, much attention has been directed to the clinical study of congenital heart lesions. This attention has already revealed that the fatalism which previously dominated clinicians' thinking is in many instances no longer justified. Two well defined entities, patent ductus arteriosus and coarctation of the aorta, can now be corrected both anatomically and physiologically by surgical procedures which can usually be expected to restore a more or less seriously handicapped patient to normal. In two other less clear cut conditions, congenital cyanotic heart disease and vascular ring anomalies of the great vessels, surgical procedures have been devised which will greatly relieve incapacitating symptoms though complete anatomical correction is not achieved. It cannot yet be confidently predicted that among the enormous number of other variations in developmental anatomy of the heart and great vessels which occur, some may be found which can be improved by surgical techniques still to be devised, but it is certain that the renewed interest in the physiology of the heart as demonstrated by these lesions and their surgical manipulation cannot fail to add much to our understanding of heart disease.

All of the procedures now in use depend upon producing changes in the great vessels of the mediastinum adjacent to the heart. No congenital lesion of the heart itself has yet been attacked directly. It follows that anatomical correction is possible only when the anomaly is limited to the great vessels. When the anomaly is within the heart it cannot be corrected but it may be possible to compensate for its physiological effects by rearrangement of the great vessels in a manner which makes no attempt to restore normal anatomy.

The four conditions now known to be suitable for surgical correction

with a reasonably clear picture of these four in mind, however, it should be possible to determine in any given case whether any operation now in use can be expected to be helpful.

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to be recognized if the ductus is small in diameter. The hilar vascular markings appear conspicuous on plates and on fluoroscopy they often show more pulsation than normal. Electrocardiograms are normal or may show left preponderance. disturbances in conduction should be considered evidence against the diagnosis of patent ductus arteriosus without other anomaly.

**Symptoms**—The effects of a patent ductus vary with the size of the patency and the consequent degree of circulatory shunt. A small ductus causes no symptoms. When the shunt is large, general effects become evident in childhood. Such children are apt to eat poorly and remain underweight. Often growth is slow and development is delayed. Obvious cardiac symptoms are rare in childhood and exercise

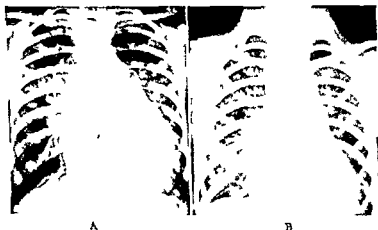


Fig 106 Patent ductus arteriosus. A Roentgenogram showing characteristic contour and pulmonary vascular congestion. B Following ligation the heart has returned toward normal. (From Caffey: *Pediatric X Ray Diagnosis*. Year Book Publishers.)

tolerance for activity of short duration may be good but endurance is diminished and exhaustion at the end of the day is frequent. Resistance to infection is also lowered, especially to respiratory infection, a history of frequent colds and recurrent bronchopneumonia being common.

**Complications**—The most dangerous complication is *subacute bacterial endarteritis* which has been shown to account for a large proportion of the deaths.

less frequent but by far

is unrelated to the size

pected in any individual with a known congenital murmur who begins



## PATENT DUCTUS ARTERIOSUS

**Anatomy**—The ductus arteriosus is a normal fetal vessel which runs as a short wide arterial trunk from the bifurcation of the pulmonary artery to the under surface of the arch of the aorta at a point opposite the left subclavian artery. Normally it closes at birth and is replaced by a cordlike structure the ligamentum arteriosum.

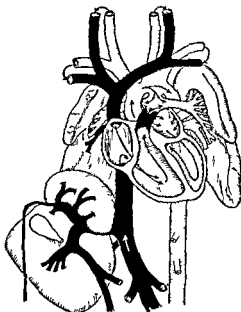


Fig 105—Patent ductus arteriosus. Diagram to show circulation (From Humphreys Nelson's Loose Leaf Surgery Vol IV)

the sternum. The pulmonic second sound is accentuated. If very loud the murmur can be felt as a thrill over the left upper chest. It is

be visible in the suprasternal region.

Roentgenogram shows enlargement of the

e shows  
ch may  
e is no

cludes a

ligation in continuity is by far the safest procedure and is usually satisfactory, though a persistent or recurrent murmur occurs more often after this procedure than after division. Division of a moderately long and thick-walled ductus can be done without adding much to the operative risk, but if the ductus is short, large in diameter, or unusually thin walled division and suture is a hazardous procedure in any but the most experienced hands.

Recovery is usually rapid, wound infection being the most serious complication since it may result in mycotic aneurysm. Results are excellent especially in those children who have shown much retardation or malnutrition. There is every reason to believe that these individuals have been restored to normal and should have a normal life expectancy.

### COARCTATION OF THE AORTA

**Anatomy.**—The aorta may be narrowed or completely closed over a short distance as a result of anomalous development. This narrowing is probably related to the involution of the bilateral aortae in early fetal life, and almost always occurs at the junction of the arch with the descending aorta just below the origin of the left subclavian artery. A slight degree of narrowing in this region is physiological at birth and it may often persist to some degree without causing any signs or symptoms. When the latter are present, the lumen of the aorta is usually narrowed to an opening of a few millimeters either by a firm cicatrix like thickening in its wall, or by a diaphragm of thickened intima. The latter may completely obstruct the lumen.

In the presence of coarctation the greater part of the blood passes around the constricted area through enlargement of the normal collateral vessels. The subclavian arteries and their subscapular and internal mammary branches are chief among these, returning blood to the lower aorta via the intercostals.

**Diagnosis.**—**Signs.**—Whenever hypertension is found in a child or young adult, the possibility of coarctation of the aorta should be considered. The diagnosis is made by the following signs and pressures:

collateral vessels of the subscapular and intercostal systems may be palpable and a bruit may be heard over them. Usually a harsh systolic murmur is heard over the base of the heart, and over the aorta posteriorly it may be louder than anteriorly. Roentgenograms show no characteristic change in cardiac contour though in adult life hypertrophy may be present as well as notching of the ribs. The level and degree of coarctation is usually well demonstrated by angiocardio-

to lose weight and run a low grade fever without obvious cause. The diagnosis depends on recovery of the organism from the blood.

*Cardiac failure* is also rare in childhood though in some instances the ductus may be so large that the individual cannot survive infancy. When failure occurs later in life it is often the left ventricle which fails first. Thus the usual signs of peripheral venous stasis may not appear, evidence of increasing pulmonary congestion sometimes accompanied by hemoptysis being the first sign. If then the right ventricular pressure comes to exceed the left venous blood may be forced from the pulmonary artery into the aorta, cyanosis becomes intense and a fatal outcome usually ensues.

**Operative Indications**—Many cardiologists now feel that operation is indicated in every child in whom the diagnosis is certain, feel

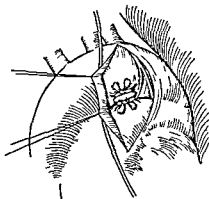


Fig 107—Patent ductus arteriosus. Appearance of the lesion at operation with ductus doubly ligated. (From Humphreys, Nelson's Loose Leaf Surgery, Vol IV.)

ing that the probabilities of late complications are a greater risk than the operative mortality of about 5 per cent. Others recalling many patients who have lived normal lives in spite of the lesion incline to restrict operation to patients actually showing symptoms. It is agreed that in adults in whom the risk is greater the operation should probably be deferred as long as no symptoms are present. In the presence of subacute endarteritis operation is indicated if the infection has failed to respond promptly to antibiotic therapy. If the infection has

arteriosus is identified carefully dissected free and a heavy ligature is passed around it. The surgeon must now decide whether to ligate

and limited to the head and upper extremities. The poor arterial supply to the legs results in claudication, weakness and coldness. Exercise tolerance may be markedly reduced from this cause.

**Complications.**—*Cerebral hemorrhage* is not infrequent and is the greatest threat if the carotid tension is already high in childhood. *Subacute endarteritis* is also a constant liability though perhaps not as great a one as in the case of patent ductus arteriosus. Late *cardiac failure* and *dissecting aneurysm* of the aorta on an arteriosclerotic basis are common terminal events, occurring frequently as early as the third or fourth decades.

**Operative Indications.**—At present the operative risk is high, and operation is therefore restricted to patients who show evidence of marked constriction in childhood. Operation is contraindicated in patients over thirty not only because degenerative disease of the aorta makes anastomosis technically hazardous but also because profound and abrupt circulatory adjustments are more difficult than in childhood. It seems probable that, with the lowering of mortality as experience increases, the indications can be extended in childhood to most cases showing significant hypertension in the hope of preventing late complications. It is doubtful, however, whether operation will ever be justifiable in the milder cases. In dealing with subacute bacterial infection, the criteria are the same as in the case of patent ductus arteriosus.

**Operation.**—The aortic arch is exposed transpleurally through a

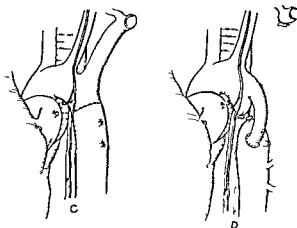
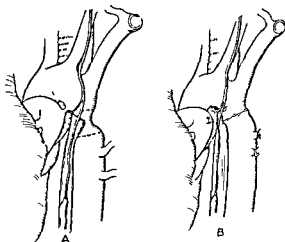
vessels supplying the esophagus in the region of the constriction

The most satisfactory method now consists of clamping the aorta above and below the constriction, excising a short segment of aorta including the constriction, anastomosis with Crafoord or suture of fine silk (C

to-side anastomosis

Sudden death may occur when the proximal aortic clamp is removed. In order to minimize this possibility the blood should be allowed to fill the lower segment slowly, either by very slow removal of the clamp, or by alternately relaxing and tightening it over the

grams. Electrocardiograms are not helpful except to exclude concomitant intracardiac anomalies



*Symptoms*—The hypertension which exists in the proximal vessels causes headache and vasomotor symptoms, often paroxysmal in type

lies it should be especially considered when these symptoms occur in a child with known congenital heart disease

Confirmatory evidence is obtained by esophagram and tracheogram using iodized oil. The esophagus will show deviation and indentation where the vessel crosses behind it which is not however always the point of maximum tracheal constriction. When the trachea is outlined both in anteroposterior and lateral projections the constriction is usually demonstrated.

**Operative Indications**—The proved existence of a vascular ring with definite obstructive symptoms is sufficient indication for operation. Not every anomaly of this type gives symptoms but the symptom free cases are unlikely to be diagnosed during life. Often the patient is an infant in poor condition and feeding by gavage or even gastrostomy may be required for a period before operation. In older children a milder syndrome may occur which becomes troublesome only with superimposed respiratory tract infection. Not infrequently a patent ductus arteriosus forms a part of the ring and the presence of these symptoms forms an added indication for operation.

**Operation**—No standard procedure can be described since the anomalies vary widely. In general an anterior left transpleural approach is most useful because division of the ligamentum arteriosum or ductus arteriosus is so frequently necessary. The operative aim is to open the ring by dividing that vessel which can most readily be sacrificed. Further opening may be accomplished by drawing the anterior vessels forward against the posterior sternum after resecting the intervening thymic tissue.

So few operations have been reported that an over all picture of results cannot be given. Gross has reported a number of apparently successful results my experience has not been so favorable.

### CONGENITAL CYANOTIC HEART DISEASE

**Anatomy**—A large number of different congenital cardiac anomalies result in more or less constant cyanosis. In every instance this cyanosis is due to mixing of venous and arterial blood in the heart or proximal aorta but in some there is in addition an obstruction to the entrance of blood into the lungs which contributes significantly to the resultant disability. It is only for the latter anomalies that operation may be helpful.

The most frequent of these is known as the *tetralogy of Fallot*. In this anomaly the aorta receives blood from both right and left ven-

tricular or interventricular mixing with diversion of blood from the lesser to the greater circulation.

period of readjustment. Rapid blood transfusion and Trendelenburg position are also advisable

During the recovery period a profound circulatory readjustment takes place which is characterized by a period of great vasomotor instability. Blood pressure varies widely from hour to hour between its preoperative level and one in normal or hypotensive range. Early rising is probably not advisable for this reason. Ultimately the symptoms are completely relieved, and it is believed that life expectancy should be increased to normal.

### "VASCULAR RING" ANOMALIES

**Anatomy**—The complicated evolution of the vessels at the base of the heart occasionally results in anomalies which create a tight vascular ring around the trachea and esophagus. Persistence of both aortic arches, one passing between spine and esophagus, is one form of anomaly. Persistent right aortic arch with left-sided descending

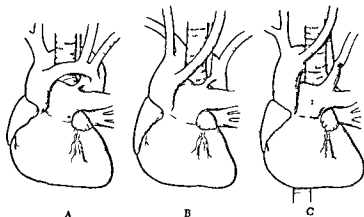


Fig 109 Vascular ring anomalies. Schematic drawings to show three types of lesions encountered at operation. A Double aortic arch (Case of Gross). B Right aortic arch with descending aorta on the left. C Right aortic arch with descending aorta on the left.

ring (Autio and Case).

aorta is another not infrequent variant which results in a ring when the ligamentum arteriosum passes downward to the left of the trachea.

ected when it is found

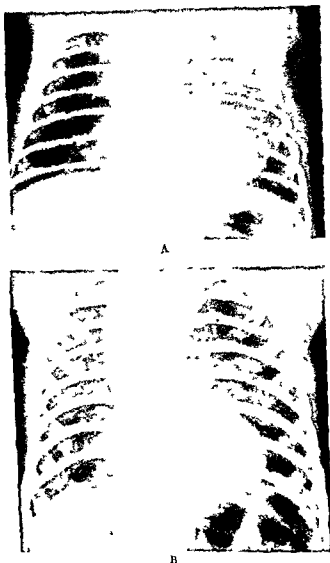


Fig 111—Tetralogy of Fallot Roentgenogram showing characteristic contour A Newborn B Same patient at 8 years

squatting posture which is assumed frequently during play. Nutrition is often poor and development slow, but some patients are both large and obese as a result of their very sedentary lives and fair circulatory status while at rest.



cold and even with emotion. Polycythemia and clubbing vary with the degree of cyanosis but play no part in differentiating this from other forms of congenital cyanotic heart disease. On x ray the cardiac contour shows a concavity in the pulmonary artery area and widening above the diaphragm due to right ventricular hypertrophy. The pulmonary vascular markings are faint. Electrocardiogram shows right axis deviation.



Fig 110—Tetralogy of Fallot. Diagram to show circulation. (From Humphreys *Cyclopedia of Medicine, Surgery and the Specialties*, F. A. Davis Co.)

Forms other than tetralogy in which diminished pulmonary blood flow is a factor, are more difficult to distinguish. The heart may be enlarged, and the murmur may be absent. Neither the extent of cyanosis nor the cardiac contour are of diagnostic value, and the electrocardiogram may show numerous and varied abnormalities. In these, determination of pulmonary blood flow and of the oxygen content and pressure of the blood in the chambers which can be entered by cardiac catheterization is of great diagnostic aid.

monary artery is first dissected free from its branches to its origin in back of the aorta. The innominate and right subclavian arteries are now dissected out of the mediastinum. The latter is clamped with a soft clamp at its origin and divided from its branches at its exit from the chest. It is then drawn through the loop of the recurrent laryngeal nerve and turned downward to permit a suture anastomosis between its cut end and the side of the pulmonary artery. If the subclavian is very small the innominate may be used and if the pulmonary artery is unusually small or friable it may be necessary to divide and ligate it proximally and to anastomose the subclavian to its distal end.

artery and the aorta (as described by Potts)

Care should be taken to maintain hydration before, during and immediately after operation to prevent further hemoconcentration and consequent liability to cerebral thrombosis. This is especially important when the innominate has been used. For the same reason transfusion should be avoided.

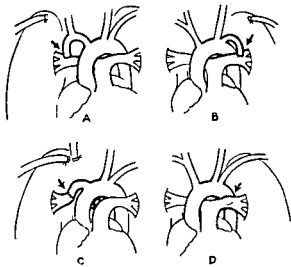
Recovery is usually remarkably rapid though slower than in the case of patent ductus. Owing to the poor muscle tone of many of these patients as well as the great readjustments they must make in circulating volume and cell concentration the maximum benefits may not be apparent for several months. Cyanosis may then become imperceptible and exercise tolerance may increase many fold. It should be borne in mind however that they carry a constant cardiac overload and they should consequently be prevented from overexertion. The danger of subacute endocarditis remains after operation and it cannot be expected that these patients will avoid cardiac failure in middle life. The increase in their ability to lead a reasonably active life in youth however justifies the procedure and brings some hope into an otherwise tragic situation.

Many surgeons have added to the accumulation of knowledge and experience in this field. The chief contributors have been Drs. Gross, Blalock and Crafoord. The former by demonstrating that a ductus

an aortic coarctation by a procedure which has now been superseded but still has a field of usefulness. More recently he has demonstrated the effectiveness of anastomoses for cyanotic heart disease in a large series of patients. Dr. Crafoord was the first to successfully excise an aortic coarctation and anastomose the aorta and he has pioneered in the surgery of the ductus arteriosus.

**Complications.**—The extreme polycythemia of the more severe cases increases blood viscosity and makes them liable to spontaneous *cerebral thrombosis*. During acutely anoxic attacks *syncope* and *convulsions* may occur without vascular occlusion. Respiratory infections are not especially frequent, but if pneumonia develops it is frequently fatal. *Subacute bacterial endocarditis* is a constant threat and the prognosis for life beyond the second decade is extremely poor.

**Operative Indications.**—Because it is technically difficult to perform an adequate operation in early infancy, operation is best postponed until the age of two or three years. If survival seems in doubt,



however, it may be done at any age. The operative risk increases sharply during the second decade and so the operation is best done

large amount of blood is best accomplished in most instances by exposing the mediastinum across the right pleura through an anterior approach. The right pul-

the heart factor is not recognized, and the embolization occurs as a complication of some critical illness particularly severe infections such as pneumonia and peritonitis. The source of the thrombus may remain quite obscure and should not influence our judgment in advising operation.

### CLINICAL PICTURE, INDICATIONS AND CONTRAINDICATIONS FOR OPERATION

The ideal case for operation is the patient with formerly good pulses in relatively normal arteries who suddenly develops a severe ischemia of an extremity. In such a patient if the arterial occlusion is at a palpable location the pulse is accentuated above the embolus and completely absent below it. A normal or even unusually high oscillometric reading is found above the lesion and a sudden shift to zero below it. The ischemia of dangerous grade is far peripheral to the actual occlusion. The degree of pain is variable. Usually it is severe and rather rapid in onset. Sometimes the patient has had milder episodes before the massive arterial occlusion occurs. Occasionally the only complaint is a cold lifeless, numb extremity. Cutaneous sensation disappears early in the presence of anoxemia. Its loss or presence is a valuable diagnostic aid in judging the degree of ischemia. Motor power, muscle joint and position sensation are lost later and indicate a more dangerous degree of anoxemia.

Occasionally one sees rapid onset of rigor mortis in the muscles from complete cessation of the circulation and death of tissues before external signs of inflammation have had time to appear. Such a case is hopeless. The extremity becomes cold and often has a pallid mottled cyanosis. If one does not operate and simply observes the process, an area of intense painful inflammation appears in the zone above the developing gangrene, often accompanied by ecchymosis, blebs and edema. This tissue is struggling for its life. The anoxemia and accumulation of harmful products of metabolism have caused complete capillary paralysis accompanied by extravasation of serum, diapedesis of red blood cells and every sign of acute inflammation. The line of

if a thrombosis has occurred in the main arterial supply and the damage is irreversible.

Unsuitable for operation are cases with advanced arterial disease with already existing extensive arterial occlusion. In such cases with badly impaired peripheral circulation almost complete ischemia of

## ARTERIAL EMBOLLECTOMY

GRANT P. PENNOYER, M.D., F.A.C.S.\*

THE sudden lodging of an embolus in a large artery vital to the blood supply of an extremity is a surgical emergency which the gen-

but when it occurs it is a dramatic, serious accident which necessitates very prompt surgical intervention to obtain a successful result. It is the purpose of this paper to discuss briefly the causes, the diagnosis, the indications for operation the surgical technic and after-care of these cases

The first successful operation restoring the normal circulation to an artery occluded by an embolus was as recent as 1911 Key of Sweden deserves great credit for popularizing the operation by reporting many cases, and now our own literature is full of brilliant examples of the value of this procedure. If a case suitable for operation is seen early, I believe the surgeon should be criticized if he does not attempt it. There is always the argument that perhaps sufficient collateral circulation will develop to prevent gangrene and the operation may be

hood of help by operation is gone by that time. Even if actual gan-

Nothing is lost by attempting removal of the obstruction and a successful result is most gratifying

Most cases of embolism to large arteries originate in disease of the left heart. Rheumatic endocarditis, valvular disease mural thrombi and valvular vegetations would obviously be sources. Auricular fibrillation ranks high as a cause, especially if there has been some recent

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demand I have seen heat start gangrene in these cases. The limb should simply be wrapped in cotton or sheet wadding and put in a bed cradle at 75° to 80° F. I have thermostats I use for this purpose in the winter months.

The location of the arterial occlusion is vital in the diagnosis and treatment. Emboli almost always lodge at important bifurcations of the artery, as at these points there is sudden diminution in the size of the lumen as the embolus travels towards the periphery. There is a striking similarity in the published experiences of all observers on this point. In the lower extremity some 4 to 5 per cent lodge at the bifurcation of the aorta. The circulation to both lower extremities may be suddenly shut off or one side may be blocked completely and the other partially. The involvement of the circulation of both lower extremities of a patient with some predisposing factor, such as auricular fibrillation, makes the diagnosis of an embolus of the aortic bifurcation easy. More and more instances of brilliantly successful operations in such cases, which would otherwise be almost surely fatal, are appearing in the literature.

Proceeding downward the next place for the lodging of an embolus would be at the bifurcation of the common iliac. About seven per cent of emboli occur at this point. The femoral artery at the origin of the profunda femoris is the next site, and over one per cent lodge here. The femoral artery is readily felt as it passes the diagnosis is very easily made at this location will have an

at this particular site and our instinctively conservative surgeon is more readily persuaded to attempt the operation. This would naturally increase the number of successful cases reported in this location, and should encourage us to attempt the operation in the less accessible places.

The next common site is at the division of the popliteal artery into the two tibial arteries. This occurs at the very lower end of the popliteal space at the upper edge of the interosseous membrane. The surgeon is apt to forget this and explore the popliteal artery too high, causing unnecessary operative dissection as he traces the artery downward to its bifurcation. Three of the five successful embolectomies

Thickening and calcified plaques of the intima of the artery in advanced arteriosclerosis may be the starting point of a thrombosis so rapid that it may be mistaken for an embolism. I have yet to see a successful embolectomy on a patient suffering from advanced peripheral arterial occlusion, and would not recommend operation in any such case. The enthusiast for the operation of embolectomy may be led astray by the sudden onset of the ischemia. I have seen several such cases in consultation with our medical confreres and always advised against operative interference. These cases are usually fatal.

The severity of the illness which the embolism complicates is not a contraindication to operation. Local anesthesia is usually all that is necessary, and the operation is not shocking. Many of the most brilliant reported results occurred in desperately sick patients. Massive gangrene in the patient already very ill means almost certain death and a successful embolectomy saving the patient as well as the limb is most gratifying.

#### NECESSITY FOR EARLY OPERATION

All observers agree that success depends upon early operation. This is a real surgical emergency necessitating immediate action. To delay until gangrene is obvious means certain failure. Secondary thrombosis in the occluded artery and irreparable damage to ischemic tissue occurs rapidly. The chances of success diminish with each hour of delay. By far the highest percentage of favorable results are obtained in cases of less than twelve hours duration. The percentage is much less by the second day and almost disappears by the third day. The surgeon must be as willing to get out of bed for these cases as he is for the strangulated hernia or the perforated peptic ulcer.

There have been some reports lately that if the extremity is chilled operation may be postponed. This is based on the theory of diminished metabolism in chilled tissue and delay of the secondary thrombosis and tissue changes. There is striking animal experimentation showing the return to life of chilled limbs cut off from their circulation for prolonged periods of time. The successful use of skin and bone grafts which have been kept in the icebox suggests this work. These cases are not parallel. I am very opposed to the application of cold in embolism or any other problem in peripheral vascular oc-

eral arterial occlusion, and the acute discomfort of these patients resulting from exposure to cold is suggestive that it may do harm.

urgent Pratt has recommended that even in these cases the artery be exposed and opened in Scarpa's triangle and that the embolus be dislodged by threading various instruments upward from this point. He reports the brilliant removal in several small pieces of a saddle embolus at the aortic bifurcation of several days duration. Personally I have seen this method attempted several times never with success. I would expect the damage to the arterial intima to vitiate the operation even if the embolus were dislodged. I would not expose the artery in Scarpa's triangle if the femoral pulse could not be felt at the inguinal ligament. In my opinion exposure at the site of obstruction is far preferable despite the added difficulties. The iliac vessels, aortic bifurcation and the whole retroperitoneal space is readily exposed from a lateral incision retracting the peritoneum and its contents medially as is done in exposure of the lumbar sympathetic ganglia and the pelvic portion of the ureter. Some surgeons have preferred a transperitoneal approach and have reported excellent results.

### POSTOPERATIVE CARE

The after-care of these patients is similar to that of other peripheral vascular occlusion problems. One must not be disappointed if the pulses below the embolectomy do not reappear immediately. It is my experience that even in some of the best cases this dramatic result may be delayed for several days and full normal pulses reappear later. The limb should be carefully protected by wrapping it in sheet wadding. I frequently use long large leggings lined with wool from discarded blankets which have been made especially for this purpose in the hospital sewing room. The limb should be kept well below heart level and never elevated. Heat or cold should never be applied. In the wintertime the temperature of the bed cradle can be kept about 80° F by thermostatically controlled lights. These thermostats are readily available and are a great source of comfort to these cases. The Pavaex boot had a great vogue and may be of some value in some cases.

### COMPLICATIONS

We have given our patients anticoagulants as secondary thrombosis is a very real problem and it occurs rapidly below the site of the embolus in the cases without operation. It may occur below the site of the embolectomy when operation is done. The exact method of administering the anticoagulants has been changed from time to time. In our early cases heparin was given by intravenous drip starting about one hour after operation. One of the patients developed such a large hematoma in Scarpa's triangle that I thought my arterial suture line was leaking. The wound was reopened after twenty-four



at Roosevelt Hospital were from the femoral artery and the other two were from the popliteal artery

Only about twelve per cent of reported cases are in the upper extremity about one half axillary and one half brachial. Gangrene will rarely occur from a brachial occlusion and infrequently after an axillary occlusion thus making the surgeon less apprehensive as to the loss of life. I believe the operation should be done on favorable cases in the upper extremity as the vascular occlusion symptoms are frequently most annoying and crippling for long periods even if gangrene does not occur

### TECHNIC OF THE OPERATION

A few words as to the technic of the operation. I wish to encourage the general surgeon to do this simple emergency operation as the vascular specialists are too few and far between to cover all these cases. No special equipment not available in any operating room is required. Very fine arterial silk attached to small atraumatic needles ready for use in sterile ampules is part of the standard equipment of operating rooms. Local anesthesia is preferable in these very sick people but this is a question which can be decided between the surgeon and the anesthetist. The artery is exposed and stripped of its adventitia so that it stands out as an isolated structure. If the diagnosis is correct the site of obstruction is obvious the pulse above it being strong and below it completely absent.

A small soft rubber catheter or a piece of umbilical tape or even a ligature of coarse braided silk is passed beneath the artery by means of an aneurism needle both well above and below the lesion. By means of traction on these the assistant can control the flow of blood from either direction and can demonstrate from which direction it is coming. This method of controlling the arterial blood flow has been criticized as too traumatic but with care it has been satisfactory in my hands and it avoids the use of special apparatus. A vascular surgeon uses guarded clamps of some sort.

A very small incision is made in the artery and the thrombus milked out. In a favorable case blood will immediately spurt freely from both directions as the assistant alternately releases the two traction loops. The incision in the artery which is usually about one half inch

## THE MANAGEMENT OF ACUTE TRAUMATIC ARTERIAL EMERGENCIES

JERE W. LORD, JR., M.D., F.A.C.S.\*, AND  
LESTER BREIDENBACH, M.D. F.A.C.S.†

AN injury to a major artery is an unusual event in civilian life. It is a fair estimate that only one or two cases are seen annually in any one of the large general hospitals in New York City. For this reason methods for the management of acute arterial injuries are usually unsatisfactory and ligation of the vessel is the definitive treatment. Ligation of a major artery frequently results in gangrene of an extremity, to be followed by amputation and sometimes loss of life. If gangrene does not develop some degree of arterial insufficiency is the rule and disability in the form of intermittent claudication remains a significant problem.

It is the purpose of this paper to describe an organizational plan including methods of technic which we believe will be successful in the management of acute traumatic arterial emergencies.

First it should be pointed out that an injury to a major artery may occur under two sets of conditions. One of these is illustrated by the street or house accident in which a knife, piece of glass, bullet or splintered fragment of bone severs an artery. The other circumstance in which arterial injury may occur is in the operating room where the vessel may be accidentally torn, divided or ligated during a hernioplasty, hysterectomy, periarterial denervation, or other operation.

We are familiar with the details of fifteen cases occurring in New York City during the past five years in which a major artery was injured either in the operating room or outside of the hospital and the definitive treatment was simply ligation of the artery. Nine amputations and one death was the final score in this group of fifteen patients.

1. A	a kitchen
table,	ie femoral
artery	1 gangrene
of the leg -- ? --	
2.	
femur	

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† Attending Surgeon, Bellevue, Misericordia and Beth David Hospitals, New York City

hours, and the artery found intact with an excellent pulse beyond the suture line. The hematoma was due to a general tissue ooze. At present our anticoagulant therapy consists of one dose of heparin in Pitkin

of diet

cumaric

prothrombin

try to keep it less than one minute. The prothrombin content of the blood expressed in percentage of normal may be a better scale. We have had no difficulty from dicumarol in any of the embolectomy group. The complications of dicumarol seem to occur in elderly people with advanced arteriosclerosis and liver diseases. These cases must be watched especially carefully, since the prothrombin time sometimes rises for nearly a week after the last dose of the drug. As I have said before, this group of patients is hardly suitable for embolectomy and this objection does not apply to them.

### SUMMARY

Sudden occlusion by an embolus of a large artery vital to the life

it is performed in the first few hours. The chances of success rapidly diminish in the second day and almost disappear by the third day. The site of the obstruction is almost always at a large bifurcation and the localization is not difficult. Operative removal requires no special apparatus not readily available in any operating room. People suffering already from advanced peripheral arterial occlusion are not suitable for this operation. The obstruction in one half of the successful cases is in the femoral artery at the origin of the profunda femoris.

The after-care of these patients is outlined.

## 2 Emergency Hospital Treatment

- A Continue above add the following
- B Morphine 0.010 to 0.020 gm sufficient to bring respirations down to 12 and control pain
- C Papaverine 0.06 gm intravenously at once repeat every three hours
- D Penicillin 100 000 units intramuscularly at once repeat every three hours
- E Tetanus antitoxin 3000 units or booster dose of toxoid
- F Paravertebral sympathetic novocain block if possible
- G Anticoagulant (heparin) only if definitive surgery must be delayed beyond six hours and there is no active bleeding—preferably given subcutaneously in 30 mg doses every two hours
- H Unless absolutely necessary do not apply clamp to artery or remove dressing until definitive surgery is to be done
- I Antishock treatment instituted promptly

## 3 Definitive Treatment

- A Proper vascular surgical equipment
- B Vascular team
- C Reestablish continuity of artery
- D It is suggested that the concomitant vein be ligated or used for vein graft if necessary
- E Sympathectomy may be of value either concomitantly or later if necessary

## 4 Postoperative Treatment

- A Anticoagulant therapy—heparin 30 mg every two hours subcutaneously until dicumarol effect is evident as determined by prothrombin time Dicumarol started by mouth as

B

C Anticoagulant therapy—continue for seven to ten days

D Continue penicillin

E Apply no heat

F Continue paravertebral sympathetic block every twelve hours as necessary

We believe that an injury to a major artery occurring during an

o Until vascular equipment is sterilized temporary control of hemorrhage may be obtained by (a) double turn of umbilical tape about artery or (b) rubber shod Allis clamp

f Establish continuity of artery by suture technic or vein graft with vitallium tubes

falling on his thigh. At operation the wound was debrided and the artery ligated. Gangrene of the leg developed in three days and a midthigh amputation was carried out.

3. An 18 year old football player sustained a posterior dislocation of the knee joint which resulted in severance of the popliteal artery and subsequent gangrene of the leg followed by amputation.

4. A 62 year old man was being operated upon for a stone in the lower ureter. The surgeon inadvertently mistook the external iliac artery for the ureter. The artery was then ligated, followed by gangrene of the leg and death subsequent to the amputation.

5. A 38 year old woman suddenly developed profuse hemorrhage while being operated upon for a broad ligament fibroid on the left side. Many clamps were blindly applied to stop the hemorrhage. One clamp completely crushed the external iliac artery which was accordingly ligated. Gangrene of the great toe occurred and inability to walk more than half a block without pain has persisted for the past six years.

6. A 50 year old man, during a carotid sinus denervation, sustained an injury to the common carotid artery which was managed by ligation. Hemiplegia occurred resulting in prolonged convalescence.

In the management of an acute traumatic arterial emergency two factors are important: first, *proper vascular equipment*, and second, *a surgeon trained in the techniques of vascular anastomosis*. We believe that the following instruments should be a part of the equipment of every operating room:

1. 2 small Blakemore Crump clamps
2. 2 rubber-shod Bambridge clamps
3. 2 rubber-shod bulldog clamps
4. 1 set vitallium vascular tubes—3 to 10 mm
5. Plastic needle holder
6. Blunt nosed eyedropper
7. Deknatel 5-0 braided silk
8. Petrolatum or mineral oil
9. Anticoagulants: dicumarol with prothrombin time control; heparin, 30 mg every two hours subcutaneously with clotting time control.

Let us examine the important points in the management of an injury occurring to a major artery outside of the hospital:

#### 1. First Aid Treatment

- A. Tourniquet—loosen every one half hour for one minute. If hemorrhage is excessive when tourniquet is loosened, control with pressure proximal to site of injury.
- B. Pressure dressing—sterile gauze to wound.
- C. Limb depressed 6 inches below heart level.
- D. Arm away from body at an angle of 45 degrees and below heart level.
- E. Apply no heat.

## 2 Emergency Hospital Treatment

A Continue above, add the following

B Morphine, 0.010 to 0.020 gm sufficient to bring respirations down to 12 and control pain

C Papaverine 0.06 gm intravenously at once, repeat every three hours

D Penicillin, 100 000 units intramuscularly at once, repeat every three hours

E Tetanus antitoxin 3000 units or booster dose of toxoid

F Paravertebral sympathetic novocain block if possible

G Anticoagulant (heparin) only if definitive surgery must be delayed beyond six hours and there is no active bleeding—preferably given subcutaneously in 30 mg doses every two hours

H Unless absolutely necessary do not apply clamp to artery or remove dressing until definitive surgery is to be done

I Antishock treatment instituted promptly

## 3 Definitive Treatment

A Proper vascular surgical equipment

B Vascular team

C Reestablish continuity of artery

D It is suggested that the concomitant vein be ligated or used for vein graft if necessary

E Sympathectomy may be of value either concomitantly or later if necessary

## 4 Postoperative Treatment

A Anticoagulant therapy—heparin, 30 mg every two hours subcutaneously until dicumarol effect is evident as determined by prothrombin time Dicumarol started by mouth as soon as convenient

B If oozing or other bleeding and give transfusion

C Anticoagulant

D Continue penicillin

E Apply no heat

F Continue paravertebral sympathetic block every twelve hours as necessary

We believe that an injury to a major artery occurring during an operative procedure should be managed as follows

1 Vascular arterial equipment available

2 Emergency consultation with vascular team

3 Until vascular equipment is sterilized, temporary control of hemorrhage may be obtained by (a) double turn of umbilical tape about artery or (b) rubber shod Allis clamp

4 Establish continuity of artery by suture technic or vein graft with vitallium tubes

5 Start anticoagulant therapy

6 Start penicillin therapy

The postoperative treatment would be precisely the same as outlined above for injuries occurring outside of the hospital

Vascular anastomosis may be accomplished in one of two ways. When an artery is merely lacerated and not completely severed, the suture technique is the method of choice. Also, when complete severance has occurred but without loss of substance, end to end anastomosis by suture is practicable. On the other hand if there has been damage or actual loss of a segment of the artery, then a vein graft should be employed. The simplest method of handling a vein graft and joining

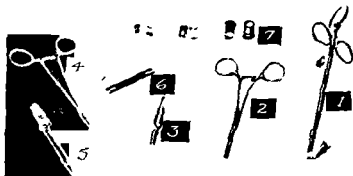


Fig. 113—Equipment for vascular anastomosis. 1 Small Blakemore Crump clamp 2 Bainbridge rubber shod clamp 3 Bulldog rubber shod clamp 4, Plastic needle holder 5, Blunt nosed eye dropper 6 Deknatel 5-0 atraumatic needle 7, Vitallium tubes

its ends to the divided ends of the artery is the two tube nonsuture vitallium technic

Successful arterial anastomosis is dependent on two basic principles the first one being *avoidance of infection* including such mildly pathogenic organisms as *Streptococcus viridans* and *Staphylococcus albus*. Infection almost invariably leads to thrombus formation at the site of anastomosis. Penicillin and anticoagulant therapy are helpful adjuncts but will not prevent thrombosis in badly contaminated wounds. Therefore thorough debridement, skin exclusion by towels and Michel clips, gentle handling of tissue, and complete hemostasis are all vital to the successful restoration of blood flow. The second basic principle is the *avoidance of longitudinal tension* at the anastomosis. No matter how beautifully the ends of the artery are sutured, failure will invariably occur if significant tension is present,

and is likely when any tension greater than physiological is permitted. Therefore if the surgeon believes that tension will ensue if an end-to-end suture anastomosis is performed he should utilize a vein graft of proper length and restore continuity by the two tube vitallium nonsuture technic.

In Figure 113 are illustrated the necessary instruments for vascular anastomosis. Although operative management of each case must be individualized in general the following steps apply. General anesthesia is preferable and measures to overcome and prevent shock are carried on concomitantly. While protecting the wound the skin around it is carefully cleansed and suitable drapes applied. With the tourniquet preventing arterial bleeding careful debridement is



Fig. 114—Trimming adventitia from end of severed artery.

carried out. Following the change of drapes, gowns, gloves and instruments, the ends of the artery are secured by rubber shoe clamps and the tourniquet released. Bleeding points are clamped and ligated and arterial anastomosis carried out.

The important steps in the direct union of the ends of the artery by suture are the following: (1) excision of the adventitia (Fig. 114); (2) irrigation of each lumen by saline using a blunt nosed eyedropper; (3) either of two suture methods may be used: (a) the classical Canel technic of placing three stay sutures of 5/0 Deknatel arterial silk (on an atraumatic needle) to triangulate the ends of the artery and complete the anastomosis by an over-and-over continuous suture; or (b) two everting mattress stay sutures are placed as in Figure 115 and the anastomosis completed by a continuous everting mattress





Fig 115. Mattress suture technique. Placing of the two mattress sutures.

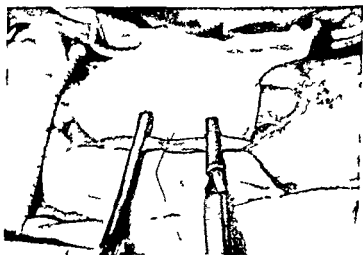


Fig 116. Mattress suture technique. Continuous mattress suture completed.

suture (Fig 116). In all but very small arteries the latter technique is preferable. (4) Following completion of the anastomosis the rubber shod clamps are removed. If any bleeding point of significance occurs

an additional interrupted mattress suture is placed. Usually steady pressure with a gauze sponge for a few minutes is sufficient to control

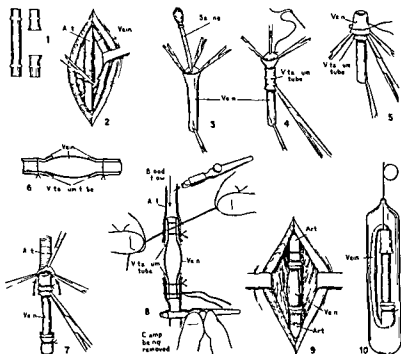


Fig. 117—Nonsuture vitallum tube technique. 1 Cannula and tubes (for use in the single or double tube techniques). 2 Removal of vein graft; note that the branch-

technique with the vein graft mounted. 7 Introducing the distal end of the vein graft

the perivascular tissues are closed snugly around the anastomosed artery when possible. 10 A convenient way of preserving hermetically sealed in an ordinary te so m tu value in military surgery.)

the tiny bleeding points (5) if there has been loss of arterial substance then in order to avoid longitudinal tension a vein graft should

be utilized. The graft may be taken from the accompanying vein or from an uninvolved leg. Occasionally the saphenous vein will be suffi

the  
the

astomosis with vein graft and tubes (6) if damage to other structures has occurred such as a severed nerve then repair may be carried out at this time, (7) the wound is carefully closed in layers with non absorbable sutures. The postoperative treatment has been detailed above



Fig. 118 - Consuture vitallium tube technic. Proximal rubber shoe clamp has already been removed and distal one is being released

We suggest that the Director of Surgery in each hospital appoint at least two men known as the vascular team who have been trained in the methods of vascular anastomosis and are subject to call at any time for the management of a major arterial injury

### CONCLUSIONS

1. Life Routine  
the artery

2. Properly performed arterial anastomosis with competent pre operative and postoperative management should largely eliminate amputation due to acute arterial injuries

3. We suggest the establishment of a trained vascular team in each hospital for the handling of these arterial emergencies. Each operating room should have the proper vascular equipment.

## ARTERIAL ANASTOMOSIS IN WAR WOUNDS OF THE EXTREMITIES

WILLIAM F MACFEE M D F A C S \*

Wounds involving the peripheral arteries are among the most distressing injuries of warfare. Such wounds may be relatively limited in extent and yet disastrous in consequence. If by chance a particular vessel is divided of the extremity, certain survival of the individual happens to be endowed and the extent of concomitant injury to the collaterals.

The incidence of arterial injuries in various wars from the Crimean to and including World War II was found by DeBakey and Simeone<sup>1</sup> to range from a low of 0.07 per cent in the American Civil War to a high of 2.4 per cent in the Russo Japanese War. The total incidence for the various American Theaters of Operation in World War II was 0.96 per cent and in wounds of the extremities the incidence of arterial injuries was approximately 1.4 per cent. It is likely, however, that the true incidence of arterial injuries in warfare is somewhat higher than the recorded statistics which are based upon casualties arriving at various hospital installations. It is certain that many soldiers with arterial wounds never reach a hospital.

### THE NATURE OF ARTERIAL WOUNDS IN MODERN WARFARE

The arterial wounds sustained in modern warfare are due almost entirely to missiles usually of high velocity. In the late war very few indeed were caused by cutting or stabbing weapons. A bullet or shell fragment moving at great speed may wound a blood vessel without actually striking it. It may injure a blood vessel or other structure for that matter by passing in the vicinity of the part. It is well known that when a high velocity missile strikes a bone fragments may be thrown about with great force as secondary missiles. It is perhaps less well recognized that such a missile striking a semiliquid substance like muscle likewise disintegrates the tissue and displaces its fragments in essentially the same manner. The impact of this disorganized matter against a neighboring blood vessel may injure it severely.

Callender<sup>2</sup> has pointed out that the kinetic energy which a bullet has and which is utilized in producing wounds is represented by the

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formula of the mass multiplied by the velocity squared divided by 2, that is  $E = \frac{MV^2}{2}$ . Wilson<sup>3</sup> has calculated that the velocity of transmission, or the time in which this energy is transmitted to the tissues is the factor of primary importance in determining wounding effects and that the wounding effect varies as the *cube of the velocity* of the missile but only as the single power of its mass. The rate of energy transmission depends also upon the density of the tissues and upon the size, or striking surface of the missile and its weight, but above all upon its velocity.

In the late World War . . . . .

### TYPES OF INJURIES AND THEIR MANAGEMENT

In treating the vascular injuries of the recent World War, it was infrequent that one dealt with a simple division or incision of a vessel. Far more often it was necessary to seek the ends of the severed vessel in the torn bloody mass of unrecognizable tissues that remained after the high velocity missile had imparted its energy to those tissues in the form of destruction. In the great majority of cases there was no choice but to ligate. Suture anastomosis was out of the question and there was absence of adequate soft tissue support for nonsuture methods. It must be remembered, too, that the vascular wound was seldom the only wound. The wounds were more likely to be multiple and the time required to attend to all the wounds made it impracticable to spend hours in what was likely to be a vain attempt to restore the continuity of a severed artery.

The peripheral arteries of greatest surgical importance were, as Rose, Hess and Welch<sup>4</sup> have indicated the axillary and brachial arteries of the upper extremity and the femoral and popliteal arteries of the lower extremity. The principal combat injuries encountered in these vessels are the following:

- **Arteriospasm.**—In some instances the injury to the vessel was indirect or slight and resulted simply in arteriospasm. This condition of spasm may be segmental, as Elkin<sup>5</sup> and Holman<sup>6</sup> have stated or it may involve virtually the entire artery and its branches, or it may

or by periarterial or a more remote form of sympathectomy. In the late war, paravertebral block with procaine was the procedure most often undertaken. The results were sometimes good, but, in general, not consistently so. It is probable the method often could not be given a fair trial in the hospitals of the combat zone, and in many instances it was used as a last resort, when gangrene had already become inevitable. Better results were obtained in hospital areas where conditions were more stable.

**Arterial Contusion.**—An artery, like any other anatomic structure, may suffer varying degrees of contusion without rupture or loss of continuity. The result of such a contusion depends largely upon its severity. If the intima is broken or devitalized, thrombosis is almost certain to occur, if it takes place slowly, time may be afforded for the development of collateral circulation. It may, however, occur in a matter of hours and interrupt the flow of blood just as effectively as if the vessel had been severed.

The thrombotic process spreads either directly or by embolism toward the terminal branches of the artery and gangrene of the extremity follows. Theoretically it should be possible to perform embolectomy in the early phase of the condition, but even if this were done it would be of little avail, because without the use of anti-coagulants thrombosis recurs, and anticoagulants cannot be used with safety in hospitals of the forward area.

Another possible result of contusion is devitalization of a limited area of blood vessel wall resulting in late hemorrhage or in the formation of a hematoma with the subsequent development of a false aneurysm. Little has been recorded about vascular contusion in World War II, but it probably has occurred more often than it has been recognized.

**Lacerated Wounds of Arteries, Incomplete.**—It occasionally happens that a missile or other wounding agent produces a laceration which extends into the lumen of an artery without completely severing it. Unless the escaping blood is contained by the surrounding soft parts and forms a hematoma, or is stopped by artificial means the hemorrhage is likely to continue to a fatal outcome. These injuries, however, if seen early, are the most satisfactory for primary repair by suture. If they arrive at the hospital many hours after wounding, thrombosis may have occurred in the distal segment of the artery, making fruitless any attempt at salvage.

**Lacerated Wounds of Arteries, Complete.**—Wounds which completely sever the artery or lacerate it beyond repair were more common than the incomplete tangential, or longitudinal rents just described.<sup>1</sup> Frequently, the wounding missile not only severs the artery but carries away or destroys a segment of it. In most instances, direct end to end anastomosis with any chance of success is out of

the question. Even in relatively simple division of an artery the ends of the vessel after a few hours retract to such an extent that it is difficult to bring them together without a prohibitive amount of tension.

It is obvious that the only practical method of rejoining the widely separated ends of such an artery is by the use of a substitute tube which can be securely fixed to the ends of the vessel and through which the blood will flow and remain liquid.

Various means have been described. One of the most interesting of these is the method described in 1942 by Blakemore, Stefko and Lord<sup>7</sup> who following a principle developed by Payr<sup>8</sup> and Hopfinger<sup>9</sup> at the beginning of the century, made use of a segment of vein which was anastomosed at either end to the proximal and distal segments of artery. By utilizing short vitallium tubes or cuffs the anastomosis was made without the aid of sutures. This nonsuture method was advanced by its designers under the hypothesis that the use of the sulfonamide drugs and the possible use of anticoagulants would afford a basis for success of such a method. In 1945 they were still of the opinion that in this war for the first time in history the success of blood vessel anastomosis was assured by the control of infection and blood clotting. The control of infection had been made more effective by the use of penicillin and Loewe<sup>10</sup> and his associates had introduced a more practical way of using heparin by introducing it subcutaneously in Pitkin's menstruum.

Another method of restoring arterial continuity is by the use of glass tubes or tubes composed of plastic material called alkathene. Both were used with limited success in our army. According to C. J. I. S. I. W. A. C. I. R. S. - 17 and distributing alkathene tubes to the Research Laboratories. It is chemically inert and can be molded or stretched to used to connect the ends of an either a vein graft or a glass tube and may be the forerunner of more satisfactory bridging material.

Blakemore and his associates treated 100 wounds of major arteries. The cases selected were those in which they felt a reasonable chance for trial of the method could be obtained. Only one patient with severe tissue damage of an extremity was selected and none in which a compound fracture existed was chosen.

Five of the patients had injuries of the femoral artery and satis-

factory anastomosis was accomplished in each case. A viable extremity was obtained in only one of the five. This patient's extremity was cool but not excessively cold, on admission, and pulsations were absent. After operation the leg became warm and pink, and remained so until evacuation. Five months later a note from the patient stated that his leg was entirely normal. The authors state, however, that the preoperative condition of this patient's leg was such that they believe collateral circulation may have played a larger role than the anastomosis in saving the leg.

In addition to the five femoral arteries, there was one nonsuture anastomosis of the third part of an axillary artery, with subsequent gangrene of the arm, in one brachial artery anastomosis, proximal to the bifurcation, the arm survived, one patient with a severed popliteal artery died on the table of a pulmonary arterial embolus after the popliteal anastomosis had been completed.

Kirtley<sup>12</sup> observed three patients upon whom popliteal nonsuture anastomosis had been performed. Two of the three patients had viable feet, but the third developed dry gangrene of all the toes. Peripheral pulses were not palpable in any of the three extremities and arteriograms showed that the medium did not go through the anastomosis. Bradford<sup>13</sup> did not find the nonsuture vein anastomosis practicable because of the time factor and increased technical difficulties, he and Moore<sup>14</sup> reported the use of glass and plastic tubes with some success. Smith<sup>15</sup> tried the nonsuture vein method in two cases, gangrene occurred in both. He was successful, however, with a plastic tube anastomosis of a severed popliteal artery. There was vigorous pulsation in the posterior tibial and dorsalis pedis arteries which continued until the seventh day and then ceased. The leg and foot became cold.

rd Army experience, showed arterial ligation than after

ries were considered, how-

ever the occurrence of gangrene after ligation was 57 per cent, after repair it was 52.8 per cent. It is not clear whether "repair" refers exclusively to anastomosis, or includes also the suture of arterial lacerations. He came to the conclusion that the nonsuture method of anastomosis described by Blakemore<sup>7, 17</sup> and his associates was impractical in the field but felt that it was a step in the right direction, and should be encouraged so that eventually better and more practical methods might be evolved.

Stewart<sup>18</sup> obtained viable extremities in three of seven attempts to restore continuity of major vessels of the extremities. In one of the successful cases a plastic tube without a vein lining was used, in the other two cases the ends of arteries were connected with vein grafts.

DeBakey and Simeone,<sup>1</sup> in their comprehensive analysis of 2471



arterial injuries occurring in World War II, found that the double-tube vein graft technic had been employed in forty cases. The incidence of amputation was somewhat greater than after other methods of repair though not to a statistically significant degree. They were not convinced the operation can be performed with the ease and celerity that military surgery demands. They mentioned fourteen cases in which the plastic tube method was employed, seven of which subsequently required amputation.

TABLE 1  
RESULTS OF NONSUTURE TUBE VEIN ANASTOMOSIS (Blakemore)

Reported by	No of Cases	Viable Extremity	Gangrene of Extremity	Per Cent of Gangrene
Odum	15	8	7	46.6
DeBakey and Simeone	40	17	23	57.5
Rose, Hess and Welch	7*	2	5	71.4
Stewart	6	2	4	66.7
Smith	2	0	2	100.0

\* The eighth patient in this series died at end of operation and is not counted.

It is apparent from the foregoing discussion that the total reported experience with arterial anastomosis under war conditions is not sufficient to warrant a clear appraisal of its value, but in Tables 1 to 5 an attempt is made to present a summary of the results obtained by the principal types of anastomosis.

TABLE 2  
RESULTS OF TUBE ANASTOMOSIS GLASS OR ALKATHENE

Reported by	No of Cases	Viable Extremity	Gangrene of Extremity	Per Cent of Gangrene
Odum	13	6	7	53.8
DeBakey and Simeone	14	7	7	50.0
Stewart	1	1	0	0.0
Bradford and Moore	5	2	3	50.0
Smith	4	1	3	75.0

A lower incidence of gangrene has followed suture repair, than any of the other methods, though it is not always clear whether suture repair refers exclusively to anastomosis or includes the simple suture of lacerated arteries as well.

TABLE 3  
RESULTS OF LIGATION OF SEVERED ARTERIES

Reported by	No of Cases	Viable Extremity	Gangrene of Extremity	Per Cent of Gangrene
Odum	767	381	386	50.0
DeBailey and Simeone	1639	837	802	48.9
Rose Hess and Welch	70	33	37	52.8
Stewart	33	17	16	48.5
Bradford and Moore	89	61	27	30.6
Smith	58	26	32	55.0

TABLE 4  
RESULTS OF SUTURE REPAIR

Reported by	No of Cases	Viable Extremity	Gangrene of Extremity	Per Cent of Gangrene
Odum	42	19	23	54.7
DeBailey and Simeone	81	52	29	35.8
Rose Hess and Welch	10	10	0	0.0
Smith	8	6	2	25.0

A compilation of the results obtained by all of the different methods of arterial anastomosis or repair is shown in Table 5.

TABLE 5  
RESULTS OBTAINED BY ALL OF THE VARIOUS METHODS EMPLOYED

Method Employed	No of Cases	Viable Extremity	Gangrene of Extremity	Per Cent of Gangrene
Nonsuture tube vein anastomosis (Blakemore)	70	29	41	58.5
Tube anastomosis glass or alkathene	37	17	20	59.5
Ligation of severed arteries	2655	1355	1300	48.9
Suture repair	141	87	54	38.3

The results that have been recorded for the various procedures are somewhat baffling to anyone who attempts to interpret them, and it is probable that the surgeons who actually carried out the treatment are no less confused by the outcome of their own efforts. This is not

arterial injuries occurring in World War II, found that the double tube vein graft technic had been employed in forty cases. The incidence of amputation was somewhat greater than after other methods of repair though not to a statistically significant degree. They were not convinced the operation can be performed with the ease and celerity that military surgery demands. They mentioned fourteen cases in which the plastic tube method was employed, seven of which subsequently required amputation.

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surprising when one considers the many variable and imponderable factors that complicate the treatment of a battle wound

**Traumatic Aneurysms**—When a lacerated artery gives rise to the formation of a hematoma, the size of the hematoma is eventually limited by the resistance of the surrounding tissue and in the course of time a capsule of fibrous tissue forms about it Gage<sup>19</sup> has given a complete and lucid description of how such a hematoma develops into a false, or traumatic aneurysm The treatment of the traumatic aneurysm is ordinarily delayed until collateral circulation is well established It may then be treated by endoaneurysmorrhaphy of Matas,<sup>20</sup> or excised The definitive treatment, however, is not undertaken until weeks or months after injury, and is not a problem of hospitals in the combat zone

**Arteriovenous Fistula**—A traumatic communication between artery and vein is known as an arteriovenous aneurysm or fistula It results in the formation of aneurysmal dilatation in the region of the fistula, which tends to increase in size The existence of an arteriovenous fistula leads to the development of a generous collateral blood supply which in three to six months time becomes sufficiently abundant to permit quadruple ligation of artery and vein with complete removal of the aneurysm On account of the necessary period of delay in treating this condition the operative procedure is ordinarily done in a general hospital

### CONCLUSIONS

1 The most important and obvious conclusion is that a satisfactory method of restoring the function of an artery severed by a high velocity missile under combat conditions is yet to be developed It is well to recognize this fact now so that further efforts will be made in that direction

2. A partial answer to the problem may reside in the prepared vein graft described by Blakemore and his associates or in the development of a more satisfactory tube prosthesis

3 The use of general anticoagulants is not safe in the forward areas where arterial wounds with the exception of traumatic aneurysms and arteriovenous fistulas must be treated Possibly an anticoagulant adaptable to local use will be found

4 The antibiotic preparations have proved their great value in preventing coccigenic and certain bacillary infections It is hoped an agent effective against the clostridia which frequently are responsible for the failure of arterial repair will be developed

5 All methods of arterial anastomosis have yielded an occasional good results in war wounds may be more responsible for



## SYMPOSIUM ON NEUROSURGERY

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### END RESULTS FOLLOWING THE CAPSULAR OPERATION FOR PARKINSONISM

JEFFERSON BROWDER, M D \*

THIS morning† there was demonstrated by operation and by dissection of formalin fixed brains a procedure for the relief of the tremor of parkinsonism. The capsular operation consisted of section of the fibers of the anterior limb of the internal capsule up to a few millimeters rostral to the genu of the capsule. This surgical section of appropriate fibers in a 26 year old male produced cessation of tremor, a favorable modification of the rigidity and a moderate degree of hemiparesis in the extremities contralateral to the side of the operation. The tremor and rigidity of the other side remained unaltered.

For demonstration this afternoon I have selected three patients, all of whom have been submitted to the "capsular operation." Several features of interest in the surgical therapy of Parkinson's disease are brought out by the results in these three patients. The first patient illustrates what should be considered a good result. The story, somewhat abbreviated, is as follows:

CASE I E C a 33 year old housewife, was admitted to the Brooklyn Hospital on April 19 1946 complaining of tremor and stiffness of the left upper extremity,

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\* Clinical Professor of Neurology and Psychiatry and Professor of Clinical

† Thursday September 11 1946  
in connection with Annual Meeting of the American College of Surgeons

regional inflammatory reaction. The facies was fixed and spontaneous winking was infrequent. The outstanding feature was the gross alternating tremor of the left upper extremity that was strikingly reduced upon purposeful movement of this part. At rest the tremor was evident in the left lower extremity synchronous with that in the left upper but less in amplitude. The rigidity component of the disease could be readily demonstrated and was also present to a slight degree in the extremities of the right side. Cogwheeling was not present on this side whereas this phenomenon could be easily demonstrated on the left. The gait was slow, the trunk bent forward, swing of the upper extremities was minimal and a slight limp favoring the left side was evident. Altogether the patient presented a typical example of parkinsonism with the major dysfunctions in the extremities of the left side.

On April 22, 1946, under local infiltration anesthesia a small right frontal bone flap was outlined and turned down. Through a transventricular approach the fibers of the anterior limb of the capsule on the right side were sectioned. There resulted hemiparesis of the extremities of the left side, cessation of tremor and marked reduction in rigidity. The postoperative course was without complications. At the end of

skis sign on this side. It seemed that the fixed facial expression was less; at any rate the patient smiled frequently and assumed a more positive attitude toward those in attendance.

*Comment*—It is now seventeen months since operation. There is no demonstrable limp. The swing of the left upper while not average is better than that of the right upper extremity. The facies is animated (the patient smiles and is interested in the audience) and there is an erect posture. Cogwheel effect is not present on either side upon flexing and extending the forearms. Tremor has not been present at any time even under emotional stress. Although the patient seems slightly slowed and overcautious in walking for her age and there is evident so-called masking of the face to the experienced observer, still I believe she could pass as normal in an average lay group of her social standing. She is still reluctant to go out alone and manifests other minor abnormal psychological reactions. In other words it appears that there is more than the obvious features of parkinsonism (tremor, rigidity and masked facies) that was and still is playing the major role in the production of this particular patient's abnormal psychological state. By contrast the result in the next patient is favorable in regards to the change in psychological status whereas the operation did not produce complete cessation of tremor.

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... as at onset the shaking was present almost con



tinuously during the waking hours. Some time during the first year of her illness the left lower extremity became moderately rigid and manifested some tremor at rest. Gradually the gait became slow, the facies somewhat masked and, because of an exhausted feeling, two hour midday resting periods were resorted to. At about 30

but this treatment gradually lost its effectiveness. During the early part of 1947 there was an insidious onset of pain in the left upper extremity, especially about the left shoulder and adjacent upper back. This was described as a burning boring pain, aggravated by the constant shaking. Up to this time she had been able to carry on with most of her household duties, but with the onset of pain in the left upper extremity there was loss of interest in the home, frequent outbursts of crying and she refused to leave the house unaccompanied. At no time had there been tremor or

had tremor ever been observed on this side. The superficial and tendon reflexes were not remarkable. There was a slight stoop when in the erect position and the gait was mildly hurried but without lurch. The patient held the left wrist with the right hand in an attempt to reduce the amplitude of the tremor, stating that this helped the pain in the left shoulder.

On April 16, 1947, under local infiltration anesthesia a right capsular operation

to walk with assistance. During the next week improvement in gait and use of the

*Comment*—The entire left upper extremity today is relatively free from rigidity. The result as regards tremor is not good although the patient says that this is not disturbing. (For example, a short outburst of tremor occurs on occasion, at which time the left wrist is

that is observed is due to insufficient section of the capsular fibers. Had about one millimeter more of the anterior limb of the capsule been divided I am relatively certain that the tremor would have been completely abolished. There is no limp and the patient holds herself quite erect. Oculogyric attacks have not occurred since operation. In this instance the patient is happier than the surgeon with the outcome of the operation.

The third patient illustrates a problem for which as yet we have no answer.

CASE III J. T., a 44 year old man, was admitted to the Brooklyn Hospital on June 2, 1946, with moderately advanced parkinsonism. In 1933 there occurred a febrile illness, said by the attending physician to have been influenza. There were no complications, certainly no subsequent feature of encephalitis. In 1938, there was first noticed slight shaking of the right hand and shortly thereafter the right lower extremity was mildly stiff. For the next five years there was a progressive slowing down of all physical activities. The facial expression became blank, the

side (Again Jennings Jackson's account regarding the case is as follows: "From this time on the disease was slowly progressive. There was a stooped posture, the arms were carried forward and without swing when walking, the eyes were mildly prominent and blinking was infrequent, and there were excessive sweating and a great enlargement of the face and hands.")

ent. While movements of the face were limited, the expression was one of wonderment rather than masking. The speech was soft and at times almost a whisper, although more forceful than it is today. The rhythmic tremor was present in all four extremities as well as mildly in the lips and tongue. The amplitude of the

seemed unimpaired

removed. For six days after the second operative procedure there was intermittent drowsiness and the tremor had disappeared altogether from both sides. With the return of consciousness and orientation the tremor and rigidity reappeared in the extremities of the right side.

Slowly over a period of some four weeks some motor power returned in the

assistance since operation however once up and about has been able to do some light work Tremor has not been present in the left upper or lower extremities during the past year There has been a moderate gain in weight over the preoperative level. The speech is almost a whisper

*Comment*—The result in this patient has been marred by the postoperative hematoma but I believe the clinical course and the present findings indicate an important point The left hand is quite mobile moreover there is no tremor either at rest or during activity In consideration of the shaking and rigidity of the right hand one would think that he would prefer to use the left for some acts at least, but this is not the case Given a handkerchief in either right or left hand, he will put it in the corresponding adjacent side pocket of his trousers about equally well with either hand When asked to pick up any object he always uses the right hand The left hand is more mobile and the grip is greater than in the right hand yet according to his wife he always prefers to use the right hand (he is right handed) The gait is slow and there is a slight limp favoring the left side

The result in this patient clearly illustrates that in bilateral parkinsonism one may produce a cessation of tremor and a reduction in rigidity of the extremities of one side by the operation that we have been carrying out This does not rehabilitate the patient in fact, this particular patient is not as well off as he was before operation We have had other examples of bilateral parkinsonism in whom the rigidity has been reduced and the tremor abolished on one side by a unilateral capsular operation with results about the same as demonstrated here In other words there is a sharp contrast between the outcome in these as compared to a successful result in instances in which the tremor and rigidity is for the most part in the extremities of one side Possibly some of these with bilateral disease may be rehabilitated by a cerebral operation on the right side and the tremor of the extremities of the left side brought under control by a posterolateral chordotomy as advocated by Putnam<sup>2</sup> In all events it is a problem that as yet has not been solved

#### REMARKS

While these three patients do not represent all the problems that confront us in the surgical treatment of parkinsonism their postoperative courses indicate certain important features Tremor and minimal rigidity of the extremities of one side can be abolished or very favorably modified by section of an appropriate amount of the anterior limb of the internal capsule of the hemisphere contralateral to the

involved extremities. Moreover this may be accomplished without paralysis. In some there is an enduring mild paresis characterized in the main by a slight limp and mild dyspraxia. In fact a slight but nonincapacitating hemiparesis is desirable otherwise after operation tremor may be precipitated by emotional stress. Again it may be well to emphasize the fact that this operation should not be carried out bilaterally. *Hamby's experience indicates the futility of simultaneous bilateral operation.*<sup>3</sup> Moreover on theoretical grounds section of a part of the anterior limb of both internal capsules is unsound. For the present at least so far as the cerebrum is concerned only unilateral operation should be performed. If the procedure of capsular section is carried out on the so called dominant hemisphere a transitory speech defect will be evident during the postoperative course but *in our experience this has cleared in six weeks to two months.* As would be expected the more marked the hemiparesis the more striking the speech defect and if the hemiparesis endures one would expect a permanent residual speech impairment.

As advocated in previous communications<sup>3, 4</sup> the selection of the patient for operation is most important. Briefly stated they should be under 50 years of age the tremor and rigidity should be limited for the most part to the extremities of one side and for one reason or another the patient should be totally incapacitated. The operation is wholly palliative and in no wise is the usual downhill course of the disease altered by the procedure. In properly selected patients however the results warrant the employment of this surgical therapy for certainly the lives of some can be made more pleasant and more useful.

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## THE SURGICAL TREATMENT OF CERTAIN INTRACRANIAL ARTERIAL ANEURYSMS

RICHARD D SWAIN M.D.\*

INTRACRANIAL aneurysms may be divided into four types—congenital arteriosclerotic mycotic and syphilitic

**Congenital Aneurysms**—Most of the aneurysms are of congenital origin and are often associated with hypoplasia of the cerebral arteries at the base. Aneurysms in this category usually have a saccular formation with a narrow neck. This type represents about 80 per cent of all intracranial aneurysms seen at operation and postmortem in this group. Evidence has been offered by many authors to support



Fig. 119. Bilateral symmetrically placed berry aneurysms of middle cerebral arteries. The left had ruptured filling the Sylvian fissures and going forward along the medial surface of the left frontal lobe and backward into the posterior fossa. (Courtesy of Dr. Harrington Martland, Chief Medical Examiner, Essex County, New Jersey.)

... of the ... berry aneurysms ...  
... and extensive ...  
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all concerned Ayer<sup>2</sup> believes that many aneurysms occurring on

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apparently healthy basal vessels may be simply mechanical developments due to the special stress and strain to which this remarkable distributing apparatus is subjected' It is not the purpose of this presentation to discuss the origin of these abnormalities but it seems to me that the weight of evidence is in favor of a congenital developmental cause The circle of Willis and its branches are prone to show anomalies and aneurysmal sacs have been found where a branch normally would have been, while others seem to develop at bifurcations It may be that they also develop at points where some of the many early embryologic branches existed

**Arteriosclerotic Aneurysms.**—Although it may be difficult to name the actual cause of an aneurysm in some instances, and knowing that some observers have reported over 50 per cent of their cases to be due to arteriosclerosis, we found only approximately 10 per cent in this series which were believed to be due to this cause

**Mycotic Aneurysms.**—Four per cent of this group were believed to be mycotic and associated with vegetative endocarditis One patient developed purulent meningitis ten days after the spontaneous rupture of the aneurysm

**Syphilitic Aneurysms.**—There were no cases which were classified as luetic in origin in this collection of cases

### SYMPTOMS AND SIGNS

The rupture of an intracranial aneurysm may present the following symptoms and signs, depending on the amount and rapidity of the leakage the location of the defect, and particularly whether it ruptures into the subarachnoid space directly or into the cerebral substance Many unruptured aneurysms have been seen at post mortem, "small, less than "in the brain W "the pulsating stream of blood into the brain substance causing much destruction before the active bleeding stops Under these circumstances it may cease before the intracranial pressure exceeds the blood pressure, causing unconsciousness, which is usually the result when the leak is directly into the subarachnoid space with no intervening tissue to aid coagulation We have often made a comparison by saying that if one drops blood into a pail of water it mixes quickly and of course does not clot but if the blood is dropped on a sponge or cloth floating in the water it will soon show some coagulation

1 Usually the first complaint is a sudden sharp pain in the head It may be unilateral, migraine type, or it may be unilateral pain in or behind either eye This may be associated with involvement of the third fourth, fifth, or sixth cranial nerves

- 2 Unconsciousness may come quickly
- 3 Headache and back pain occur
- 4 Rigidity of the neck is observed

8 Papilledema is usually not present in acute hemorrhage but may appear days later



10 11 12

am ner Essex County New Jersey )

9 Hemiplegia complete or partial without unconsciousness indicates that the middle cerebral artery was the site of the rupture If y

tion of aneurysm

11 Convulsions if focal may help localization and occur most commonly in leakage from the middle cerebral artery causing brain damage They may also appear after several days or weeks due to irritation by the false sac around the aneurysm

## TREATMENT

There is no specific treatment for this condition except in those instances when surgery is indicated. *We think that lumbar puncture, after the initial small diagnostic tap, may be definitely harmful, especially in a case where one has reason to believe that the bleeding has stopped.* However, I did see a typical case recently in which an aggressive physician performed a full pneumoencephalogram with no apparent harmful effect. The resulting x ray films, however, were "negative." This method of treatment should fully satisfy even the most rabid of those who believe in removing all the blood from the subarachnoid space to prevent sequelae.

There are unquestionably many intracranial aneurysms which are amenable to surgical treatment. The ones to be reported here are in the group generally considered to be the least hopeful, namely, ruptured aneurysms of the left middle cerebral artery in right handed people.

## Case I

He wanted to say

When seen a few hours later at the hospital the picture was that of a right partial hemiplegia in a disoriented and aphasic male. (There was an additional story of this man having been treated for diabetes about one year previously and that he had

right although difficult to test because of his state of consciousness, there was no doubt that he had a nominal aphasia and at least a partial if not complete right homonymous hemianopsia.

Lumbar puncture showed spinal fluid pressure to be 220 mm of water and slightly blood tinged. Cell count was erythrocytes 43 000, leukocytes 58, with 60 per cent polymorphonuclears. Urine showed 1 plus sugar, and the blood sugar was 200 mg per 100 cc.

At this time it was believed that the diagnosis should be ruptured aneurysm of the left middle cerebral artery or brain tumor left temporal with hemorrhage.

*Operation and Subsequent Course*—The ventriculogram was reported as showing absence of an inferior horn in left lateral ventricle and no shift of the ventricular system. An osteoplastic flap



evidently fresh bleeding. The searcher was left in place and the dura opened widely. The appearance of the cortex was not remarkable. A horizontal incision was made into the temporal lobe, following the searcher, with the electrosurgical cutting current attached to a suction tip. At a depth of 1.5 cm. a cavity full of some old blood and fresh

that the sac of a small aneurysm can be pulled into the opening of the suction tube and held there, the ordinary suction tip having an opening which is too small. This special tip affords an almost bloodless field so that the process of clipping off the neck of the aneurysm, or its coagulation, can proceed in the proper manner without the usual almost blind procedure with the definite danger of the current damaging other important structures.

In this case the objective was accomplished without thrombosing the middle cerebral artery. The patient recovered after four weeks with no residual symptoms except a slight nominal aphasia for approximately twelve weeks.

*Comment*—This and the following cases prove that some of the ruptured congenital aneurysms of the middle cerebral artery can be satisfactorily treated surgically without clipping or thrombosing the artery itself, with the resulting hemiplegia and possible permanent aphasia.

## Case II

lower face and arm

*Operation and Subsequent Course*—After a diagnosis of ruptured aneurysm of the left middle cerebral artery had been made a left fronto-temporo-parietal osteoplastic flap was turned down. A searcher passed into the temporal lobe revealed nothing. The dura was then opened and the approach to the possible aneurysm was made through the sylvian fissure, saving most of the superficial vessels. It was soon seen that the aneurysm had not ruptured into the temporal lobe but superiorly into the parietal lobe. Active bleeding was encountered but by using two suctions the bleeding aneurysm could be picked up in the special suction tip. In this instance the neck of the sac could be clipped and the sac very slowly coagulated to avoid permanent thrombosis of the middle cerebral artery.

This boy has made a complete recovery

Paralysis of lateral gaze from a lesion in this region of the brain had not been previously observed by me

### Case III

lose consciousness entirely Since this attack five days before this last admission to the hospital, he had seemed confused mentally His headache had persisted

Examination revealed an apprehensive patient somewhat euphoric and also dis

ache became worse The induced nystagmus after turning was normal Lumbar puncture showed a bloody fluid under a pressure of 260 mm of water Red cell count was 800 000 white cells 250 total protein 180 mg per 100 cc colloidal gold curve 0023320000 and Wassermann test negative The fluid was slightly xanthochromic after being centrifuged

Blood examination was normal and the Kahn test was negative Urinalysis showed normal findings and the blood pressure was 144/90

*Operation and Subsequent Course*—The patient's condition became gradually worse His headache persisted and his mental confusion and aphasia increased On the eleventh day after admission his left internal carotid was exposed under local anesthesia It has often been reported that patients having congenital intracranial aneurysms are likely to have other anomalies of their vascular system and in this case there was apparently no left common carotid the external and internal carotids originating separately from the subclavian

With x ray plate and tube in position an exposure was made (one second) while 10 cc of diodrast was being injected into the internal carotid through a No 19 needle Five seconds later another film was exposed

While the wound was being sutured the patient became pale and clammy and stopped talking although he was conscious He also had a right hemiparesis chiefly the right face, hand and forearm After

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ly aphasic

As can be seen from the photograph of the angiogram (Fig 121) he had a complete thrombosis of his left middle cerebral artery and had developed a demonstrable collateral circulation around the original blow out near the lower motor area. The diodrast could not have caused this thrombosis otherwise some of the opaque solution would be in the artery. The second film taken five seconds later showed no arterial outline the medium having passed on but did show a shadow (also visible in this picture) representing the aneurysm and the leakage around it into the false sac. The diodrast however did cause the thrombosis in some of the vessels of his recently developed collateral



Fig 121 Arteriogram in Case III

circulation bringing on the immediate collapse a few minutes after

the anterior cerebral artery to block one of the recently developed collateral circulation

Strangely enough his headache has almost entirely disappeared. If it becomes a factor again or if there is evidence of another rupture with bleeding exploration will be done. We would expect to find a small aneurysm with a larger false sac the result of previous hemor

rhage into the cerebral tissue. The fact that the false sac is connected with the true sac does not show in the arteriogram.

#### Case IV

A 17 year old boy was admitted to the Newark Eye and Ear Infirmary in a semi comatose condition. His father said that ten days previously while at work he sud-

has not been entirely conscious or able to talk since the onset and the right side

fluid at this time was under a pressure of 340 mm. of water and was slightly xanthochromic. The diagnosis was ruptured aneurysm or neoplasm with hemorrhage.

*Operation and Subsequent Course*—A left osteoplastic flap was made in the left temporoparietal region. Upon opening the dura some bloody fluid was evacuated. The cortex of the temporal lobe was flattened. A searcher passed into it contacted some resistance at 2 cm. then a sudden gush of clotted and fresh blood appeared. Incision was made through the cortex into a softened hemorrhagic area and enough bleeding to require two suctions before visibility was good. After picking up the bleeding point in the suction tip it was coagulated and the bleeding controlled. It could be seen that the brain had been destroyed by the hemorrhage and softening extended far medially.

The patient was allowed to go home sixteen days after the operation and talk but was the fact that to optic atrophy surprisingly his condition has improved until he now sees O D 20/50 O S 20/200. Both visual fields are telescopic. He is able to walk fairly well but the right arm has lost 40 per cent of its efficiency. He has no nominal aphasia but there is a slight hesitancy in his speech. Fortunately his mental condition is very good.

This boy should have been operated upon much earlier before so much damage was done particularly to the optic nerves.

#### SUMMARY

1 Four cases of ruptured aneurysm of the left middle cerebral artery or its branches are presented briefly two cases were cured and one case was improved by surgery.

2 The three surgical cases will have no recurrences unless they have other aneurysms.

3 The method of picking up the bleeding sac in the suction protects adjacent structures from damage and saves time

4 It would seem that earlier operation is advisable in the type of case here described

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## CEREBRAL ARTERIOGRAPHY

SIDNEY W GROSS M D F A C S \*

CEREBRAL arteriography was introduced by Moniz<sup>1</sup> in 1927. This valuable adjunct to neurologic diagnosis did not gain popular approval in this country until relatively recently. Most of the objections to cerebral arteriography have been overcome by simplifications in the technique and by the introduction of diodrast<sup>2</sup> as the radiographic medium.

### TECHNIC

Cerebral arteriography is most often carried out by injection of either the common or the internal carotid artery after exposure of the vessel surgically. If visualization of the circulation of the posterior fossa is desired it is necessary to inject either the vertebral artery directly or the subclavian while occluding the artery distal to the point of puncture and occluding also the thyrocervical trunk. Before the contemplated arteriography the patient should have an intradermal or conjunctival test to rule out hypersensitivity to diodrast.

If general intravenous anesthesia is employed. If the operator chooses to inject the common carotid artery this vessel is exposed by means of a small incision just above the clavicle and parallel to it. To inject the internal carotid the bifurcation is exposed by means of an 8 cm incision along the anterior border of the sternomastoid muscle beginning at the angle of the jaw. The vessel to be injected is then isolated from surrounding structures with a narrow tape. The head is placed in position for a lateral x-ray film and preparations are made for a rapid exposure on a signal from the operator. Perfect coordination between the operator and x-ray technician is imperative. The artery is then punctured with a curved 17 gauge needle having a rubber tubing connection (Fig. 122). A syringe containing 15 cc of a 35 per cent solution of diodrast (35-diiodo-4-pyridone-N-acetic acid diethanolamine) is attached to the rubber connector. After insuring that the needle is within the lumen of the artery by allowing a small amount of blood to run into the diodrast solution the injection is

rapidly completed X ray films are rapidly exposed during the injection. The operator gives the signal after about 8 cc of diodrast have been injected. If a stereoscopic pair is desired a second injection is done. Usually a single lateral and an anteroposterior view provide the desired information.

Technics for the direct injection of the common and internal carotid arteries without incising the skin have been described by Loman and Myerson,<sup>3</sup> Turnbull,<sup>4</sup> and Ecker and Chamberlain.<sup>5</sup> I have had no experience with any of these "blind" methods. Operative exposure of the common carotid artery is the method of choice. It has thus added advantage if a lesion which might be benefited by ligation of the

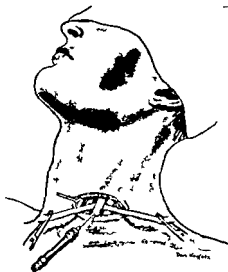


Fig 122—Exposure of common carotid artery

common carotid is disclosed the ligation can be done at the same time as soon as the wet films have been interpreted.

Vertebral arteriography may be done by direct injection of the vertebral artery as recommended by King<sup>6</sup> or by the indirect method described by Moniz. In the latter technic the subclavian artery is exposed by an incision just above the clavicle and parallel to it. The phrenic nerve is identified on the scalenus anticus muscle. Both these structures are retracted mesially. It may be necessary to divide the scalenus anticus muscle. Narrow Penrose drains are placed around the subclavian artery and thyrocervical trunk to occlude these vessels and force the radiographic medium to flow into the vertebral circula

tion after being injected into the subclavian artery against the direction of flow

### THE NORMAL ARTERIOGRAM

The configuration of the normal arteriogram is well known (Figure 123) The internal carotid artery enters the skull through the carotid canal at the tip of the petrous apex Variations in the intracranial portion of the internal carotid artery occur frequently According to Moniz it forms a simple S curve in 31 per cent a double S curve in 39 per cent and a transitional form in 30 per cent The ophthalmic artery is the first large intracranial branch extending forward just below the level of the anterior clinoid to enter the orbit through the



Fig 123 —Normal arteriogram

optic foramen The posterior communicating and posterior cerebral arteries are rarely visualized in carotid arteriograms The anterior choroidal artery is the last branch of the internal carotid artery before its division into anterior and middle cerebral arteries The middle cerebral artery is seen dividing into posterior temporal angular and posterior parietal arteries The anterior cerebral artery passes forward and upward branching into the frontopolar callosomarginal and pericallosal arteries

### INDICATIONS FOR CEREBRAL ARTERIOGRAPHY

The introduction of a safe radiographic medium diodrast has greatly extended the use of cerebral arteriography<sup>7</sup> It is indicated



for the detection and localization of intracranial aneurysms, intracranial vascular malformations, arteriovenous fistulas and vascular tumors. Cerebral arteriography is also indicated for the localization of brain tumors when the results of pneumoencephalographic examinations are not conclusive, or in the poor risk case where the removal of cerebrospinal fluid from the ventricular system for the injection of air or oxygen might prove catastrophic. Cerebral arteriography has recently been employed in the diagnosis and treatment of spontaneous subarachnoid hemorrhage.\*

### ILLUSTRATIVE CASE HISTORIES

The following cases demonstrate the value of cerebral arteriography.

**CASE I** A white woman, 35 years of age, had had headaches for several years attributed to sinusitis. The day before admission she suddenly became dizzy com-



Fig. 124 (Case I) —Saccular aneurysm of internal carotid artery

plained of nausea, headache and weakness and began to vomit. The next day she had a violent pounding pain in her head, and when seen a few hours later she was uncon-

into middle and anterior cerebral arteries (Fig 124). The left common carotid artery was ligated as soon as the wet film had been read. The patient tolerated this procedure very well. She became more alert and cooperative and left the hospital ten days later.

*Comment*—The rupture of an aneurysm of the circle of Willis is a frequent cause of subarachnoid hemorrhage. Such hemorrhages prove fatal in the first attack in 30 per cent. In patients who survive the initial rupture of an intracranial aneurysm there is a 20 per cent mortality in the succeeding year.<sup>9</sup> Cerebral arteriography provides a method for localizing such intracranial aneurysms, the first step in rational treatment, be it ligation of the carotid artery in the neck or intracranially.

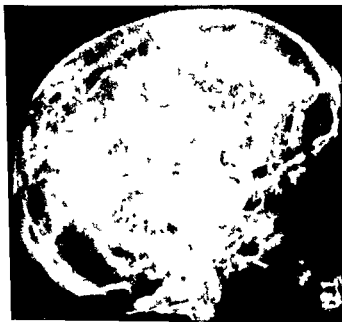


Fig 125 (Case II)—Vascular malformation

for the detection and localization of intracranial aneurysms intracranial vascular malformations, arteriovenous fistulas and vascular tumors. Cerebral arteriography is also indicated for the localization of brain tumors when the results of pneumoencephalographic examinations are not conclusive, or in the poor risk case where the removal of cerebrospinal fluid from the ventricular system for the injection of air or oxygen might prove catastrophic. Cerebral arteriography has recently been employed in the diagnosis and treatment of spontaneous subarachnoid hemorrhage.<sup>8</sup>

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The following cases demonstrate the value of cerebral arteriography.

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Fig. 194 (Case I) —Saccular aneurysm of internal carotid artery

1 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100

## SUMMARY

The three case histories cited above are typical of many in which cerebral arteriography was the most important single factor leading to correct diagnosis and treatment. Cerebral arteriography is finally coming into more general use and its indications are becoming more clearly defined. It is a superior method for detecting and localizing intracranial aneurysms, vascular malformations, arteriovenous fistulas and vascular tumors. Cerebral arteriography provides a means for differentiating between aneurysm and tumor. It also gives valuable information regarding the probable histologic nature of an intracranial mass. Finally, cerebral arteriography with 35 per cent diodrast is much safer than ventriculography in the poor risk patient.

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*Comment*—This case demonstrates the value of arteriography where the clinical study alone does not permit a positive diagnosis. Carotid ligation is done in these cases to reduce the blood flow through the vascular malformation and thus decrease the tendency for bleeding.

(Fig. 126) showed a downward displacement of the sylvian vessels. The tumor



Fig. 126 (Case III) — Meningioma outlined by blood vessels

was outlined by arteries in its capsule indicated by arrows in Figure 126. A left temporal craniotomy disclosed a meningioma of the sylvian fissure. This was completely removed. The patient has been followed for almost one year and has been restored to almost normal health.

*Comment*—In this case the arteriogram was decisive. While a brain tumor was considered, most observers believed the patient had vascular disease. The disclosure of alterations in the cerebral arteries indicating a tumor was followed by successful surgical intervention and recovery.

existence of this little recognized clinical entity and to indicate what may be accomplished with this lesion by surgical means

### CASE REPORT

H. H. (J.H.B. No. 296039), a 46 year old man was admitted to the Jewish Hos-

of admission to the hospital. At the time of the patient's admission he was believed to be suffering from a subarachnoid hemorrhage.

Four years previously the patient had had an episode of severe headache lasting five weeks. During the subsequent two to three months he was troubled with extreme dizziness and nausea on turning his head. This occurred mostly during the night. At no time was tinnitus or impairment of hearing noted. A similar attack in milder form occurred two months prior to admission and lasted about two weeks.

Examination on admission disclosed no abnormalities in the general systemic status. The neurologic examination could be performed only with difficulty since the patient's vertigo was aggravated by movement of the head and eyes. The positive neurologic findings included marked nystagmus on right and left lateral gaze, more marked in the former position; limitation of lateral gaze to the left; small sluggishly reacting pupils; marked asynergia; dysidiadochokinesis and hypotonia in the left upper and lower extremities; more so in the upper; positive Holmes's phenomenon referable to the left upper limb; marked nuchal rigidity and blurring of the nasal margins of both optic disks associated with slight venous engorgement.

Routine blood and urine studies were negative. X-rays of the skull and chest were not significant.

Lumbar puncture performed on the day of admission revealed grossly bloody cerebrospinal fluid (28,000 red cells per cu. mm.) under a pressure of 350 mm. of water. A second spinal tap on September 30 showed the cerebrospinal fluid to be xanthochromic and under a pressure of 270 mm. of water (110 red cells per cu. mm.). Electroencephalographic examination revealed the presence of a diffuse electrical abnormality moderate in degree which affected all areas anterior to the occiput.

The clinical picture to this point suggested subarachnoid hemorrhage secondary

became disoriented and presented a dysarthria. Accordingly ventriculographic study was carried out on October 2, 1946. This disclosed symmetrical enlargement of both lateral and third ventricles.

**Operation and Subsequent Course**—This accumulation of findings suggested hydrocephalus secondary to an expanding left cerebellar lesion. Since the patient improved somewhat following ventriculography and since the clinical picture suggested a clot, no longer of recent origin, operation was deferred. However, because of subsequent deterioration of the patient's condition, it was decided to carry out a cerebellar exploration.

This was performed on October 17, 1946, a suboccipital craniectomy

## SPONTANEOUS INTRACEREBELLAR HEMORRHAGE- SURGICAL TREATMENT

JOSEPH H. STRIS, M.D., F.A.C.S.\* AND AARON J. BELLER, M.D.†

HEMORRHAGE within the substance of the cerebrum is common and

which represented an incidence of less than 1 per cent among all types of intracranial hemorrhage. On the other hand Mitchell and Angrist<sup>2</sup> found an incidence of 10 per cent among one hundred and fifteen cases of spontaneous intracranial hemorrhage, a figure which compares favorably with those of Charcot, and Bouchard and Bashan, cited by Torkaldsen.<sup>3</sup> Mitchell and Angrist point out that intracerebellar hemorrhage is no less frequent than intracerebral hemorrhage, when one considers that the ratio by weight of these structures is approximately 1:10. Thus, it appears that this condition is not a rarity, and it is not easy to understand why it is rarely diagnosed clinically, and is only encountered as an autopsy finding.

Intracerebellar hemorrhage, like the intracerebral variety, may be due to arteriosclerosis with or without hypertension, aneurysm, trauma, syphilis, acute infectious diseases and blood dyscrasias. Evans and his associates<sup>4</sup> reported two cases of traumatic hemorrhage in which calcification was found only in the small blood vessels of the cerebellum, thus suggesting the existence of a local vascular factor and resultant predisposition to bleeding.

Though numerous instances of spontaneous intracerebellar hemorrhage have been recorded in the literature, only isolated reports of premortem recognition and surgical treatment of this condition are to be found, the great majority of them having been necropsy studies.

On the basis of this experience and of those recorded in the literature, it appears that the diagnosis of intracerebellar hemorrhage may be made in certain instances. The comparative rarity with which one encounters the diagnosis clinically is mainly due to the fact that patients with this disorder generally succumb within a few hours of the time of onset of the hemorrhage. This in all probability is due to rupture into the fourth ventricle which causes compression of the vital medullary centers. In the occasional case which survives this period the clinical picture presented is that of sudden onset of headache associated with dizziness, nausea and vomiting. Cerebellar signs and signs of increased intracranial pressure appear very early. Thus pathognomonic signs are not present here.

intr the cerebellum with or without associated subarachnoid hemorrhage should have the benefit of air studies if at all possible. If these show the ventricular system to be symmetrically dilated an examination of the cerebellum is warranted. In an occasional case one's diagnostic and therapeutic efforts will be rewarded by cure.

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being carried out under general anesthesia. The left cerebellar hemisphere was found to be larger than the right and did not pulsate. A puncture of the left hemisphere yielded 10 cc. of old blood at a depth of 3 cm. from the surface following which the cerebellum began to pulsate. An incision was made into the cerebellar hemisphere down to the area of the clot. No site of origin for the clot could be found. Some of the grayish brown tissue of the surrounding wall was removed for biopsy. This did not show any pathologic change. It was concluded that regardless of the nature of the underlying lesion, the blood must have reached the subarachnoid space either by rupture into the fourth ventricle or into the cerebello-medullary cistern.

Postoperatively the patient's condition improved markedly. The dizziness, vomiting, headache and paresis of the left external rectus muscle disappeared completely. There was a decrease in cerebellar signs in the left upper and lower extremities. The papilledema increased in the first few days after the operation but then began to disappear.

An electroencephalogram taken on November 19, 1946, showed a definite decrease in per cent time and amplitude of potentials slower than 8 per second in comparison with the preoperative record. Series of high amplitude 2.5-4 per second potentials were not recorded at this time.

The patient was last seen on June 13, 1947, eight months after operation. His only complaint was a tendency to deviate to the left on walking long distances. Neurologic examination revealed normal eyegrounds and absence of nystagmus. There was very slight asynergia in the left limbs. Gait was remarkably good but some ataxia could be evoked after having the patient walk a good deal.

#### COMMENT

At the time of the patient's admission to the hospital a diagnosis of subarachnoid hemorrhage secondary to ruptured aneurysm or bleeding from vascular neoplasm in the posterior fossa was made. It was believed that a conservative course should be followed until bleeding stopped. The advancing left cerebellar signs and papilledema, however, led to the suspicion of an intracerebellar hemorrhage for which reason it was decided to explore the patient. Despite the finding of intracerebellar hemorrhage, careful exploration failed to reveal the primary cause for this bleeding.

It is felt that the progressive improvement which has been maintained at this relatively late date tends to exclude neoplastic disease. An extended follow up is planned, however, before this conclusion is accepted as valid.

development of the hydrocephalus. The fluid produced in the lateral ventricles enters the third ventricle through the foramen of Monro and leaves by way of the aqueduct of Sylvius to appear in the fourth ventricle. It finally reaches the subarachnoid space emerging from the fourth ventricle through the medial foramen (Magendie) and the lateral foramina (Luschka). The subsequent course of the cerebrospinal fluid is downward in the spinal subarachnoid space and upward and forward under the base of the brain, finally ascending over the convexities of the cerebral hemispheres. There is no unanimity of opinion concerning the mode of absorption of the cerebrospinal fluid. According to Weed,<sup>21</sup> absorption largely takes place by way of the arachnoid villi into the venous sinuses, though some fluid may also leave by way of the perivascular spaces. As a result of their experiments on the excretion of dyes introduced into the subarachnoid space, Dandy and Blackfan<sup>7</sup> believed that the absorption of the cerebrospinal fluid occurs by way of the capillaries throughout the subarachnoid space. More recently Dandy<sup>3</sup> has shown that separation of the villi from the

subarachnoid spaces without appreciable participation of the choroid plexuses. This led them to conclude that dissolved substances pass from capillary plasma into a pericapillary and perineuronal space constituting the extracellular tissue space, and from there into the subarachnoid fluid. Thus, their findings indicated an extraventricular elaboration of cerebrospinal fluid. If this hypothesis is correct and accounted for the *only* method of cerebrospinal fluid formation, the theoretic basis of the operation of choroid plexectomy would be seriously open to question. However, both experimental and clinical evidence exist to prove that at least part of the source of cerebro-

spinal fluid is derived from the choroid plexuses. <sup>11</sup> Measurement of the rates at which "tagged" ions present in the blood plasma appeared in the cerebrospinal fluid indicated that this was generally a slow process, unlike the formation of tissue fluids elsewhere.

In any case, whether the fluid is secreted or filtered through the choroid plexuses, a lesion which obstructs the outflow of cerebrospinal fluid from the ventricles into the subarachnoid space or one which interferes with its absorption from the subarachnoid space will

# HYDROCEPHALUS, AND HYDROCEPHALUS WITH MENINGOCELE

## Their Treatment by Choroid Plexectomy

LEO M. DAVIDOFF, M.D., F.A.C.S.\*

HYDROCEPHALUS in infancy, resulting as it does in abnormal enlargement of the head, is so obvious a disturbance that its recognition goes back to the twilight of history. In the earliest medical literature extant, some mention is made of it and some measures, however ineffectual, are suggested for its treatment. Thus, even in Hippocratic writings, one finds a brief passage referring to "dropsies coming from the head."

In reporting (1929) still another method in the surgical approach to the treatment of this condition—a method, by the way, which bore little fruit—I reviewed in some detail<sup>1</sup> the numerous suggestions—medical, physical and surgical—that were made over the centuries, and especially the last 100 years, in attempts to arrest hydrocephalus. In that review one method of treatment, namely the resection of the choroid plexuses, was referred to as "serious transcortical operations which appear too drastic to be justifiable." This conclusion was based on reports in the literature then available of fifteen cases by seven different writers with only three of the fifteen patients surviving the operation.

In recent years, however, choroid plexectomy for the treatment of infantile hydrocephalus has become an established procedure. It is an operation which was devised as a consequence of a better understanding of the physiology of the cerebrospinal fluid circulation and of the pathogenesis of hydrocephalus and improvements in technique have markedly reduced the surgical hazards.

### PATHOLOGIC PHYSIOLOGY

The basic problems of the site and means of formation of the cerebrospinal fluid have been extensively discussed in the literature and will be dealt with briefly here. The commonly held view is that cerebrospinal fluid is formed mainly by the choroid plexuses within the ventricles. Evidence to substantiate this contention was afforded by Dandy<sup>2</sup> who demonstrated that unilateral internal hydrocephalus resulted from experimental occlusion of one foramen of Monro. Simultaneous extirpation of the choroid plexus, however, prevented the

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continuous traction in the brain stem there occurs an aseptic inflammation of the basilar cisterns which results in blocking the flow of cerebrospinal fluid to the cerebral subarachnoid space. Lastly it is conceivable that some instances of hydrocephalus are due to defective absorption of the cerebrospinal fluid owing to an impairment of function of the arachnoid villi a view originally proposed by Cushing<sup>2</sup>

### TREATMENT

A variety of surgical procedures have been devised in an attempt to divert the flow of cerebrospinal fluid into other tissues.<sup>9</sup> None of them have met with any degree of success and have largely been abandoned. The operation most widely practiced today in the treatment of hydrocephalus is that of choroid plexectomy. It has become an established procedure in a large measure as a result of the work of Dandy.<sup>3</sup> He maintained that if a sufficient amount of choroid plexus were destroyed a satisfactory balance between the production and absorption of cerebrospinal fluid could be achieved. Hence he proposed that it be employed in cases of communicating hydrocephalus. For obstructive hydrocephalus he recommended sidetracking the cerebrospinal fluid by means of third ventriculostomy. Although Dandy's operative statistics have not been published other surgeons have reported their results. Of the twenty patients with nonobstructive hydrocephalus operated upon by Scriver<sup>10</sup> three died as a result of the operation seven failed to derive any benefit and in the remainder a lasting reduction of intracranial pressure was achieved. Nine of the last group of children were reported to be alive. Of these four appeared to possess normal mentality three showed moderate retardation and two marked retardation. Sachs<sup>17</sup> treated ninety eight hydrocephalics over a 25 year period. This included fifty four cases of communicating hydrocephalus. In this group there were twenty two recoveries and twenty seven deaths recorded six of the deaths occurring from extraneous causes one to two years after operation. A unilateral or bilateral plexectomy was performed in forty two of the fifty four cases. There were twenty five deaths in this group five occurring one or more years after operation. At least five of the survivors who had been followed for a minimum of one year were reported to have done well. Seven of the group of forty two obstructive hydrocephalics were subjected to choroid plexectomy. In only one case was improvement recorded. This occurred in a five year old patient a case of postmeningitic obstructive hydrocephalus who was relieved of the obstruction by severance of adhesions found in the posterior fossa. Subsequently the hydrocephalus changed to the communicating variety and a choroid plexectomy and a uretero arachnoid anastomosis were performed. None of the remaining six cases survived. Four of these patients had cerebellar explorations done

result in excess accumulation of fluid under increased pressure. Theoretically, hydrocephalus might also result from excess formation of cerebrospinal fluid but, according to Dandy,<sup>8</sup> this rarely, if ever occurs, unless it be in connection with an adenoma of the choroid plexus, as reported by Davis and Cushing.<sup>10</sup> Occlusion of the vein of Galen, which drains the choroid plexuses, has been considered a possible cause of hydrocephalus. Dandy and Blackfan<sup>7</sup> favored such a view, but were able to produce this sequence of events in only one of ten experimental animals. Subsequently Bedford,<sup>1</sup> who obstructed the vein of Galen in a large series of dogs, reported that collateral circulation was rapidly and adequately established so that in no case did hydrocephalus ensue.

Dandy and Blackfan,<sup>8</sup> who investigated the subject of infantile hydrocephalus in great detail, believed that obstruction somewhere along the course of the cerebrospinal pathways occurred in practically every case. The term "communicating hydrocephalus" was applied to those cases in which no interference to the flow of cerebrospinal fluid between the ventricles and subarachnoid space existed. Where a block which prevented the egress of cerebrospinal fluid into the subarachnoid space was demonstrated, the case was designated as one of noncommunicating or "obstructive hydrocephalus." To distinguish the two types of hydrocephalus a small quantity of a neutral preparation of phenolsulfonphthalein was injected into the ventricle. Prompt recovery of the dye in the lumbar subarachnoid space indicated that the hydrocephalus was of the communicating variety.

Noncommunicating hydrocephalus may result from obstruction of the aqueduct of Sylvius or from occlusion of the foramina of Luschka and Magendie. Obliteration of the aqueduct in infancy usually results from congenital atresia. Occlusion of the foramina of Luschka and Magendie may be congenital in origin or the result of inflammatory cicatrization. Communicating hydrocephalus is brought about by blockage of the cerebrospinal fluid in the basilar cisterns so that the fluid fails to reach the sulci of the cerebral hemispheres. Obstructions in the cisterna are probably, in the majority of cases, of congenital origin, due to failure of development of the arachnoid spaces.

Occasionally the Arnold Chiari malformation, a congenital anomaly characterized by a prolongation of the cerebellum and brain stem into the cervical portion of the spinal canal and a frequent accompaniment of meningocele, is responsible for the occurrence of

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at the foramen magnum. A third possibility is that, as a result of

there was a preceding meningitis the respective organism being the meningococcus pneumococcus type II B coli and an unidentified gram positive coccus Two of these postmeningitic hydrocephalics have done well since operation one having been followed for a period of three years

In nine of the thirty two cases there was an associated meningocele Treatment of the hydrocephalus received priority in each instance so as to reduce the intracranial pressure and the tension within the meningocele thereby simplifying management of the meningocele (Figure 127) In view of the frequency with which these anomalies co-exist it is the practice in this clinic to delay surgical intervention in patients with meningocele for varying lengths of time This is done for several reasons first to determine whether or not a complicating hydrocephalus will develop secondly because the operation is better

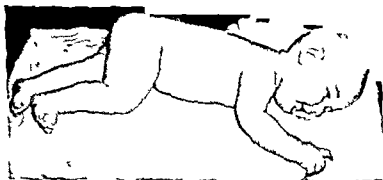


Fig 127—Baby with meningocele and hydrocephalus seven months postoperatively showing a large meningocele practically completely regressed

tolerated by an older infant Even if the skin overlying the mass is thin and threatening rupture, or the lesion is actually discharging, it is preferable to temporize Assiduous care including the use of alcohol dressings protective cotton rings and chemotherapy is indicated to help tide the patient over such a critical state This may however permit entry of infection into the cerebrospinal fluid spaces as was probably the fact in Case I and critical judgment must be exercised in determining the optimum time for operation

I do not quite share the opinion of Ingraham and Hamlin that in cases in which hydrocephalus follows the removal of a meningocele there is no causal relation It is true that the hydrocephalus may not develop because of the removal of the meningocele sac but the sac often acts as a safety valve for the hydrocephalus and can be made worse after the former is closed

as well Putnam<sup>14 15</sup> has analyzed his results in several articles, the most recent of which appeared in 1943. He divided his cases into two groups, depending on whether they were operated upon before or after 1935. The earlier series represented cases done during the developmental period of the operation. There were seventeen cases in this group on whom a total of thirty six operations had been performed. Of these, only two patients survived, seven were "hospital deaths" and eight died at a later date. In the second series, there were twenty five patients, the number of operations on these being thirty five. A total of fourteen survived, four were listed as "hospital deaths" and seven succumbed subsequently. Putnam indicated that there appeared to exist a correlation between mortality and mentality. Thus, of ten patients with an apparently normal mentality before operation, four survived after intervals of five to seven years. On the other hand, of twenty patients known to have defective intelligence prior to operation seventeen eventually expired. A follow up study of six cases seemingly normal at the time of operation and five of which were previously reported by the author in 1938 is included. Four of the patients were still alive and progressing well. Putnam concluded that coagulation of the choroid plexuses should be attempted in all cases of infantile hydrocephalus in whom a reasonably normal mentality could be demonstrated unless contraindicated by other complications.

#### AUTHOR'S MATERIAL

I have operated upon thirty two babies by the choroid plexectomy procedure for the relief of hydrocephalus. The clinical diagnosis was confirmed by means of ventriculography or by ventricular estimation. In a few cases differentiation between communicating and obstructive hydrocephalus was attempted by means of the phenolsulfonphthalein or combined ventricular and lumbar puncture tests. Contradictory results were obtained at times when both tests were done so that they were not made part of the routine examination. It is my distinct impression that it is not particularly important or helpful to determine whether a given case belongs in the communicating or noncommunicating category. Choroid plexectomy would appear to be indicated

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tory distress was obtained in thirteen instances. In four of the cases

These infants tolerate the loss of body heat poorly so that precautions must be observed to keep them warm. It is also advisable to supply parenteral fluid during the operation. This was formerly done by cutting down on a vein and supplying normal saline solution intravenously. More recently we have found that hypodermoclysis suffices.

For purposes of orientation, after the scalp is shaved and prepared with an antiseptic solution lines corresponding to the Rolandic fissure and midsagittal plane are marked with gentian violet. A small horse-shoe shaped flap of scalp and bone is turned in the temporo-parieto-occipital region (Figure 128). Heavy scissors suffice to cut the thin bone once an opening has been established. If the intracranial tension is excessive and the dura tense, pressure may be relieved by puncturing the ventricle. The dura is opened and the ventricle exposed by incising the cortex with the electrocautery suction apparatus after coagulating the surface blood vessels. Narrow ribbon retractors are used to prevent the walls of the ventricle from collapsing as it is emptied of cerebrospinal fluid by suction. The choroid plexus is exposed in the body and temporal horn of the ventricle. With a bayonet forceps the glomus and as much of the plexus in the temporal horn as is possible are coagulated. If it is feasible to do so it may be excised between clips. The ventricle is filled with warm normal Ringer's solution. We have tried both saving and replacing the original cerebrospinal fluid and using artificial cerebrospinal fluid (Hartmann's solution). We were however not able to see any advantage in these over warm carefully prepared Ringer's solution.

No special endoscopic instruments are employed. They make excision of the plexus more difficult than the use of the bayonet forceps. The plexus is coagulated with the electrocautery.

With a metal clip or perchance the coagulation has opened a blood vessel. Moreover we regard it as safer for the underlying basal ganglia and thalamus to lift up the portion of the plexus to be coagulated and then apply the current than to burn the tissue as it lies against these structures.

## RESULTS

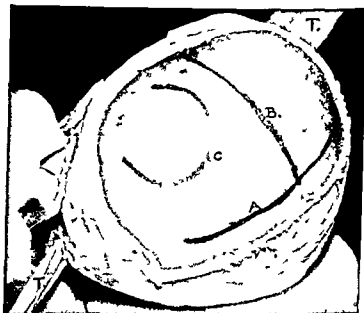
For the first three patients the results were as follows:

from the parents. One patient expired following cauterization of the choroid plexus in the fourth ventricle and another following a lamina terminalis puncture. Both these operations were performed after bi-



## TECHNICAL POINTS

In treating a case of *hydrocephalus by choroid plexectomy* in contrast to Dandy's procedure the operation is performed on only one side initially. This may suffice to arrest the course of the disease. A period of observation of ten days to four weeks is instituted and, in the event there is further enlargement of the head the procedure is repeated on the other side. Formerly the anesthesia employed routinely was a combination of local infiltration with 0.5 per cent novocain and



a dilute whiskey and sugar solution sucked from a baby bottle. More recently, especially in the older infants, local infiltration has been combined with avertin by rectum. This has proved highly satisfactory.

To prevent the cranial bones from collapsing when the ventricle is entered, a plaster cast is applied in the form of a ring encompassing the forehead and occiput. A plaster cast encasing the whole head except for a small opening for the operation, as recommended by Dandy, does not seem to be necessary.

the hydrocephalus. The fifth patient is the one who is now awaiting the second operation three months after the initial one because of progressive enlargement of the head.\*

Special mention should be made of the results obtained in the nine cases of hydrocephalus associated with meningocele. Two patients with the combined lesion died postoperatively. One of these was the child (Case I) who died from complicating meningitis but in whom mechanically the hydrocephalus seemed to have been arrested and the meningocele receded. In three cases, the hydrocephalus was arrested and the meningocele healed spontaneously after operation. One of these three cases was that of a child in whom a unilateral choroid plexectomy sufficed to bring about the desired results.

In four cases the meningocele required surgical repair. One of these patients made a seemingly satisfactory adjustment to this additional procedure. One child had a normal sized head and a large occipital meningoencephalocele. This was repaired prior to the choroid plexectomies but the sac refilled. After both lateral ventricle choroid plexuses were removed, the sac largely receded, but the last operation was only two months ago. A third child in this group had a thoracic meningocele which showed only slight regression after a unilateral plexectomy, but the hydrocephalus appeared to be arrested. Twenty months later, the meningocele was resected, largely for cosmetic reasons, and about one week later, the baby began to show signs of increased intracranial pressure which disappeared after the other choroid plexus was resected (Case VII).

The fourth child had both choroid plexus removed and the meningocele repaired but is showing slowly progressive hydrocephalus.

### CASE REPORTS

The following case histories will illustrate a few of the problems and situations encountered in this series.

**CASE I (J V, J H No 282745)**—*Lumbar meningocele. Observation and subsequent development of progressive hydrocephalus. Right choroid plexectomy. Death from meningitis probably originating in meningocele.*

This infant born prematurely was first seen on February 20, 1945, when 8 days old because of a large lumbar meningocele. The skin overlying the men-

\* This operation has been successfully completed since this paper was written and five additional cases successfully treated by bilateral choroid plexectomy.

lateral coagulation of the plexuses within the lateral ventricles had failed to halt the progress of the disease. Infection was the cause of death in three instances. In one of these cases the same organism (pneumococcus), which was responsible for the meningitis which precipitated the hydrocephalus, was the cause of the postoperative infection. The second child died of an infection resulting from necrosis of the wound edges from prolonged pressure of an extremely large and heavy head. The third baby (Case I) in this group developed diarrhea postoperatively and expired four weeks later. Post mortem examination showed a purulent meningitis caused by a hemolytic streptococcus infection. In this instance the source of the infection was probably from the meningocele.

Eleven patients who have been followed for periods varying from one to four years have done well. Their hydrocephalus has been



Fig 129



Fig 130



Fig 131

Fig 129. 130. 131. 132. 133. 134. 135. 136. 137. 138. 139. 140. 141. 142. 143. 144. 145. 146. 147. 148. 149. 150. 151. 152. 153. 154. 155. 156. 157. 158. 159. 160. 161. 162. 163. 164. 165. 166. 167. 168. 169. 170. 171. 172. 173. 174. 175. 176. 177. 178. 179. 180. 181. 182. 183. 184. 185. 186. 187. 188. 189. 190. 191. 192. 193. 194. 195. 196. 197. 198. 199. 200. 201. 202. 203. 204. 205. 206. 207. 208. 209. 210. 211. 212. 213. 214. 215. 216. 217. 218. 219. 220. 221. 222. 223. 224. 225. 226. 227. 228. 229. 230. 231. 232. 233. 234. 235. 236. 237. 238. 239. 240. 241. 242. 243. 244. 245. 246. 247. 248. 249. 250. 251. 252. 253. 254. 255. 256. 257. 258. 259. 260. 261. 262. 263. 264. 265. 266. 267. 268. 269. 270. 271. 272. 273. 274. 275. 276. 277. 278. 279. 280. 281. 282. 283. 284. 285. 286. 287. 288. 289. 290. 291. 292. 293. 294. 295. 296. 297. 298. 299. 300. 301. 302. 303. 304. 305. 306. 307. 308. 309. 310. 311. 312. 313. 314. 315. 316. 317. 318. 319. 320. 321. 322. 323. 324. 325. 326. 327. 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flap was turned 650 cc of cerebrospinal fluid evacuated from the ventricle and the choroid plexus coagulated. The patient's postoperative course was marred by pneumonia which fortunately responded to chemotherapy. At the time of discharge

slightly

**CASE IV (J. G., J. H. No. 263417) —Congenital communicating hydrocephalus. Bilateral choroid plexectomy. Well after three and one half years**

This infant was born prematurely during the eighth month of gestation and at the time of birth weighed 3 pounds 12½ ounces. He appeared to be making satisfactory progress until the age of 6 months at which time enlargement of the head was first noticed. At the time of admission to the hospital on March 31, 1913, the circumference of his head measured 48.5 cm. His neurologic status was in no way



Fig 132



Fig 133

Fig 132 Case IV appearance of patient at 10 months of age before operation  
Fig 133—Same patient as in Figure 132 at 3½ years of age

formed on April 13, 1943. Postoperatively severe diarrhea developed and despite a variety of treatment the baby died on April 16, 1943. Postmortem examination disclosed a purulent meningitis caused by a hemolytic streptococcus.

It is noteworthy that following operation there was a considerable decrease in the size and state of tension of the myelomeningocele (Fig. 1).

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CASE III (R. N. J. H. No. 243980) — Congenital hydrocephalus communicating? Unilateral plectomy. Well after four years.

At the age of two months this baby's head was noted to be larger than normal. Growth and development were otherwise not retarded. When the infant was first

Unfortunately he had developed nephrosis, but from a neuropsychiatric standpoint, he was unchanged. He was alert and happy and his head showed no further enlargement.

**CASE VII (F W, J H No AA78382, M H No 41461)—Infantile hydrocephalus, cervicodorsal meningocele. Right choroid plexectomy with arrest of hydrocephalus. Recurrence of hydrocephalus, following excision of meningocele. Left choroid plexectomy with improvement.**

This infant was first seen in February, 1945 at the age of 8 months because

accentuation of the digital markings indicative of increased intracranial pressure. The patient was admitted to the hospital where ventriculographic studies were performed. These showed a considerable dilatation of the ventricular system. On April 11, 1945 a right choroid plexectomy was performed. Following operation the child did well and when seen about a month later the fontanelle was scaphoid and the meningocele slightly smaller. During the six months period between May and November, 1945 the circumference of the head remained unchanged (52 cm.). On December 4, 1945 the patient was readmitted to the hospital for the purpose of repairing the meningocele. At that time the child was still unimpaired. The meningocele was repaired on December 6, 1945. At that time the child was still unimpaired.

## SUMMARY

Thirty-two infants with congenital hydrocephalus were operated upon by unilateral or bilateral choroid plexectomy. In nine of the cases there was an associated meningocele.

The operations were done by applying a plaster ring around the patient's head to prevent the bones from collapsing. No ventriculoscope was used.

In cases with associated meningocele, the hydrocephalus was

do so. There she died.

1944 and 1953)

**CASE V (M. S., J. H. No. 260831) —***Meningococcus meningitis followed by hydrocephalus. Bilateral choroid plexectomy. Well after four years.*

At the age of 4 weeks, this baby developed a febrile illness, accompanied by vomiting and several episodes during which she would "stiffen out." Except for tense fontanelles, physical examination on admission to the hospital on January 2, 1943 was negative. A blood count revealed 37,400 white cells with a preponderance of polymorphonuclear leukocytes. Lumbar puncture showed cloudy, xanthochromic fluid containing 7700 white blood cells, 98 per cent of which were polymorphonuclear.

begin to bulge. Ventricular drainage

her head measured 54.5 cm.

**CASE VI (M. L., J. H. No. 280111) —***Hydrocephalus following B. coli meningitis. Bilateral choroid plexectomy. Doing well two years after operation.*

1944 at the age of 11 months, his head measured 54 cm. in circumference, the

Unfortunately he had developed nephrosis but from a neuropsychiatric standpoint, he was unchanged. He was alert and happy and his head showed no further enlargement.

**CASE VII (F W, J H No AA78382 M H No 41461—Infantile hydrocephalus cervicodorsal meningocele. Right choroid plexectomy with arrest of hydrocephalus. Recurrence of hydrocephalus, following excision of meningocele. Left choroid plexectomy with improvement.)**

This infant was first seen in February 1945 at the age of 8 months because of progressive enlargement of the head and inability to sit up. He was born at full term, forceps having been applied to facilitate delivery. A mass was noted at that time in the upper dorsal region. Enlargement of the thymus was diagnosed soon after birth and x ray therapy administered.

When the patient was examined at the age of 8 months there existed an obvious hydrocephalus the circumference of the head measuring 49.5 cm. In addition there was a meningocele at the level of the cervicodorsal spine. Skull films revealed accentuation of the digital markings indicative of increased intracranial pressure. The patient was admitted to the hospital where ventriculographic studies were performed. These showed a considerable dilatation of the ventricular system. On April 11, 1945 a right choroid plexectomy was performed. Following operation the child did well and when seen about a month later the fontanelle was scaphoid and the meningocele slightly smaller. During the six months period between May and November 1945 the circumference of the head remained unchanged (52 cm.). On December 4, 1946 the patient was readmitted to the hospital for the purpose of repairing the meningocele. At that time he appeared to possess normal intelligence his vision was good and he had learned to control his sphincters. He was

cells. The child's status remained unchanged till about the third postoperative day. He then became untable, began to vomit and developed a bilateral abducens palsy. The optic nerve heads which previously had been observed to be normal were now blurred and the retinal veins full. It was obvious the child was suffering from a recurrence of increased intracranial pressure. For a short time he seemed to improve and the right abducens weakness disappeared. Signs of increased pressure re-

appeared but a left choroid plexectomy is performed. Following this operation the right abducens weakness became much more pronounced and the left abducens palsy became less pronounced. At the time of discharge on January 5, 1947 the hydrocephalus appeared to have become arrested once more.

### SUMMARY

Thirty-two infants with congenital hydrocephalus were operated upon by unilateral or bilateral choroid plexectomy. In nine of the cases there was an associated meningocele.

The operations were done by applying a plaster ring around the patient's head to prevent the bones from collapsing. No ventriculoscope was used.

In cases with associated meningocele the hydrocephalus was





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## VISUAL FIELD STUDIES IN NEUROSURGERY

MAX CHAMLIN, M D \*

ONE of the important functions of the ophthalmologist in neurosurgical diagnosis is the study of the visual fields. While in some cases it does not help, in others it corroborates a previous diagnosis, and in still others it may furnish the most important criteria for diagnosis and surgery.

The normal visual field depends on the integrity of the visual pathways, so that any interference with the pathways will give corresponding changes in the visual fields, and lesions not interfering with the visual pathways will yield normal fields. The very lack of interference with the visual pathways may be of clinical significance where the existence of a tumor is made known by other means.

An intracranial mass may interfere with the visual pathways in one of two ways: (1) direct pressure by the mass upon the pathways, their blood supply or the immediately surrounding tissues, (2) obstruction of the normal flow of cerebrospinal fluid causing generalized increased intracranial pressure and papilledema.

Where a lesion does not interfere either directly or indirectly with the visual pathways, such as in early parasagittal or frontal lobe tumors, the peripheral visual fields are apt to be normal and therefore, of no help in localizing, lateralizing or even establishing the existence of a tumor. In such cases, one obtains far more information from the electroencephalogram or air studies. Such tumors are not apt to cause papilledema early and, therefore, the study of visual fields does not help except in a negative way.

On the other hand, tumors that cause generalized increased intracranial pressure early may give early *enlargement of the blind spot* sufficient to make the diagnosis of papilledema fairly reasonable even when ophthalmoscopic findings are still questionable. Such findings are frequent in tumors of the posterior fossa and tumors blocking the ventricular system, such as third ventricle tumors, with no localizing effect on the peripheral fields. Such a case is seen in Figure 134 in which the history and physical examination, including skull plates

fail to suggest further studies at risk  
ial  
of

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hyperopia in each eye and, for this reason, several of the examiners were inclined to believe that appearance of the disk was due to pseudopapilledema. However, persistent and definite enlargement of the blind spots was accepted as evidence that this was true papilledema. Pseudopapilledema should not cause enlargement of blind spots.<sup>1</sup> Therefore, air studies were done, and an obstruction of the third ventricle was discovered. Operation revealed a third ventricle tumor which was surgically removed.

Another case in which the discovery of a brain tumor was made possible through the study of visual fields\* is shown in Figure 135.

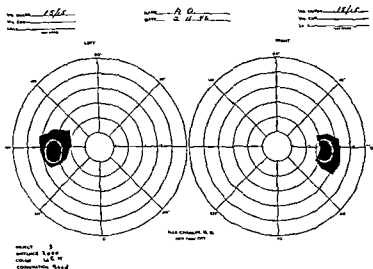


Fig. 134—Definite enlargement of the blind spots in a case in which the nature of the blurring of the disks was questionable. This enlargement made the diagnosis of papilledema quite definite.

This was a 21 year old female nurse, who was generally considered psychoneurotic. The disks were only slightly suggestive of papilledema.

In both the above cases, there was not enough indication for air studies until the enlarged blind spots were discovered. For early enlargement of the blind spot, one must use minimal types of stimuli and careful interpretation. Before considering a small degree of enlargement as pathological, one must be careful to rule out funduscopically visible local causes such as peripapillary choroidal degen-

eration of myopia, chorioretinitis juxtapapillaris, large scleral crescents, choroidal sclerosis, medullated nerve fibers, as well as closely grouped retinal vessels causing large angioscotomas

In differentiating papilledema from optic neuritis, visual field study is of paramount importance and may, in the early stages, be the only way of distinguishing the two conditions. This point was emphasized by the author in a recent article,<sup>2</sup> and illustrated by a case presented in that article. In this case, there was bilateral optic neuritis with retention of good central vision. This particular patient complained of headache and, therefore,\* in view of the bilaterality of the fundus

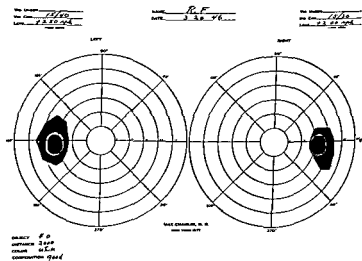


Fig. 135—Definite enlargement of the blind spots in a case in which a question of blurring of the disks was present. This enlargement was the first real evidence of papilledema.

findings and the retention of good central visual acuity as measured on the Snellen chart, was considered to have a brain tumor. However, the patient had para scotomas e further

course of the case bore out this diagnosis.

In temporal, parietal and occipital lobe lesions, the patients are apt to have *homonymous field defects* of various types depending on the site of interference, and that often serves to corroborate the existence of a tumor determined by other means. However, where other

findings are minimal or questionable, a definite homonymous field defect can be of great importance in diagnosing a postchiasmal lesion, as demonstrated in Figure 136

Perhaps one of the most practical uses of perimetry is found in *chiasmal* and *prechiasmal lesions*. A large percentage of lesions in the region of the chiasm may cause visual field defects and this interference with vision may be the first symptom to bring the patient to a doctor. The patient may complain of defective vision before he is conscious of any headache or changes referable to malfunctions of the pituitary gland. Such a case is shown in Figure 137. While ad-

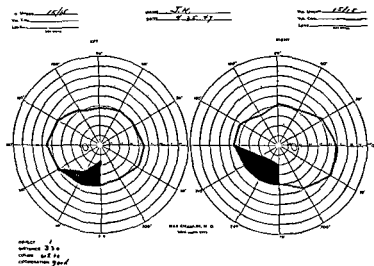


Fig 136—A small amount of left homonymous field defect giving definite evidence of interference with the visual pathways and definite lateralization

vanced lesions of the chiasmal area will give the classical bitemporal hemianopia, even the earliest ones, when carefully studied on the tangent screen, will often show enough hemianopic characteristics to localize the interference in the chiasmal area. Such cases, in the early stages, are not infrequently passed off as retrobulbar neuritis unless very careful perimetry is done.

Chiasmal interference may be demonstrated by the visual field studies when other findings, including x-rays, are noninformative. This is seen in

In such cases, the hemianopic features of the field

serve to place the lesion in the region of the chiasma, while the lack of pituitary malfunction diminishes the likelihood of an intrasellar pituitary tumor

Where the interference is far forward, well away from chiasm, the differentiation between *retrobulbar neuritis* and a mass lesion may be quite difficult. However, sooner or later, such lesions involve the chiasm to some extent so that careful perimetry will bring out some hemianopic defects in one or both eyes. Such hemianopic features may be missed unless varying quantitative and qualitative tests are used. In such instances, the use of red test objects is often helpful. However, this differentiation of prechiasmal mass lesions from retro-

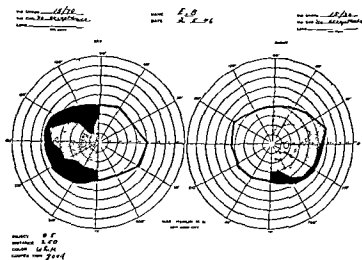


Fig 137.—Field findings in a case of pituitary adenoma. This patient had no symptoms save for some blurring in the left eye

bulbar neuritis will often pose serious diagnostic problems, and even with the most careful perimetry, may remain difficult of solution. Of course, in most cases, careful field studies and clinical examination of the visual field may be sufficient to suggest a prechiasmal mass lesion. In such cases, the patient may be suspicious of a mass lesion, and the patient may be suspicious of a mass lesion. In such cases, the patient may be suspicious of a mass lesion, and the patient may be suspicious of a mass lesion.

Such cases warrant angiography and air studies to rule out tumors and aneurysms. If the presence of a tumor or an aneurysm cannot be established by those means, and the patient continues to lose vision, one might even be justified in exploring surgically, since

a suprasellar meningioma not showing up on x ray may be found and removed thus saving the patient from going blind and perhaps from losing his life

Finally in cases of brain tumor where the diagnosis depends to a great extent on the finding of *optic atrophy* and the fundusoscopic appearance is questionable perimetry becomes very important In such cases physiological temporal pallor may be difficult to differentiate from true pathological pallor and a normal visual field will speak for physiological pallor while a defect in the field will point to true atrophy In such cases one must not content himself with routine field studies but must use minimal stimuli in order to detect minimal evidence of interference in the various portions of the field

### SUMMARY

The study of visual fields is of great aid in diagnosing and localizing brain tumors While the findings may be only corroborative in some cases in others they may be the only evidence to stimulate further studies which lead to the discovery of a brain tumor In still other lesions visual field studies may be the most important findings to indicate the existence and location of a mass lesion and help to differentiate the condition from inflammatory lesions of the optic nerve and chiasm

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## THE REPAIR OF FACIAL PARALYSIS OF OTTIC ORIGIN

THOMAS G. TICKLE, M.D.\*

THE first attempt to "cure" facial paralysis by surgical means was probably made by Drobnick, in 1879, when he anastomosed the spinal accessory nerve to the facial nerve with some beneficial results—as some of his confrères reported, however, the first recorded operation was done by Ballance, in 1895, who did perform and record the same operation. While the results were fairly satisfactory in that movements of the facial muscles were partially restored, nevertheless there were annoying associated movements, i.e., when an attempt was made to

pens when the hypoglossal nerve is used half of the tongue partially atrophies and the same annoying associated movements occur especially when the patient is eating.

Many cases of anastomosis were reported both in this country and abroad but their results were far from satisfactory. Duel and Ballance experimenting on monkeys and baboons—and after trying out the different nerves used in the previous anastomosis operations—advocated, in 1932, the direct line repair as the operation of choice in these cases. Although, in 1930, Bunnell<sup>1</sup> had operated in a case of facial paralysis using a piece of sural nerve from the leg to bridge the dehiscence and thus had restored the facial movements this was unknown to them. I believe that the universal use of the direct line repair in restoring function to a paralyzed face is undoubtedly due to the extensive work on animals and humans undertaken by Ballance and Duel.

Any nerve can be used for this type of graft, be it motor or sensory—reversed or unreversed, but, of course, a sensory nerve is preferable as no muscle is paralyzed when this nerve is used. Degenerated and heteroplasic nerves can also be used, in fact, they were used by Duel and myself in quite a number of cases with equally good results. Duel advocated, and subsequently used, only a degenerated nerve, for he thought that with it the time of recovery would be shortened and the end results possibly better, but this has not proved to be true. The idea of degenerating the nerve was that when it is severed it undergoes what is known as wallerian degeneration. In a degen

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erated nerve one has a set of empty tubules through which it was thought the new neurons growing down would all pass but this is not entirely true as most of the neurons grow along the sheath I prefer the use of fresh grafts for the reason that it eliminates the preparatory operation as well as a longer hospitalization

There are two types of cases that are suitable for operation (1) those due to injury and (2) those resulting from a toxic infection such as acute otitis media acute mastoiditis chronic mastoiditis and the so called "Bell's"—or refrigeration—palsy

### FACIAL PARALYSIS DUE TO INJURY

In those cases of facial paralysis due to injury, especially following a mastoidectomy where the paralysis is complete upon recovery from the anesthetic one can be reasonably sure that the nerve has either been severed or badly damaged I believe that these cases should be investigated immediately or just as soon as the response to faradic stimulation is lost This response to faradic current as shown by the experiments on the monkeys and baboons is lost within a period of from forty eight to seventy two hours if the nerve has been severed or badly damaged While the response to faradic current is not the "last word" in the testing of nerves I think it is one of the best indications thus far advocated of what has happened to a nerve I rely greatly upon this reaction together with my clinical experience gained over a number of years in the observation of over three hundred cases of facial paralysis upon which I have operated In cases in which there is a loss of faradic response and the angle of the mouth in repose is drooping the tonus of the muscle has been lost however where there is a loss of faradic response and the angle of the mouth in repose is nearly even one may surmise that there is a slender connection left—enough to supply tonus to the muscles These are the cases over which one can debate the advisability of an operation or a period of wishful waiting

Paralysis that comes on several days after an operation or injury always means that the ——— and some fibers have been pushed through the sheath formed or a neuritis off the impulses through the opened A daily test

If the response to the current is lost and the angle of the mouth in repose starts drooping then one is justified in uncovering the nerve and investigating should the response to faradic stimulation be returned regardless of how complete the facial paralysis surgery is contraindicated because I have never seen a case of this kind in which recovery did not occur There has been much controversy as to

whether one is justified in waiting for infection to clear up. Let me say that infection is no contraindication to either a nerve graft or a decompression operation, my results have been equally as good in both infected and noninfected cases. This fact I believe has now been conceded by other operators.

**Operation.**—A postauricular incision is made regardless of whether the previous operation was done endauricularly or postauricularly, the perosteum is retracted and the old mastoid cavity exposed, the sternomastoid and the posterior belly of the digastric muscle are freed from the tip of the mastoid, the tip of the mastoid is bitten off (I use a small pair of rongeurs) and the facial nerve is exposed at the stylo-mastoid foramen. With this procedure it is much easier to uncover and find the nerve at this site than with any other method—especially if the previous operation was done a few months before. Since the mastoid cavity nearly always will be filled with granulations and scar tissue it is impossible by other means to recognize or pick up the nerve in this cavity. If a search is made for the nerve in order to uncover it up to the site of the previous injury, I am sure that if it has not already been cut or badly damaged, it will be at the end of the operation! Of course, if the operation was very recent, it will be possible to uncover the nerve starting from the site of the injury, nevertheless, the easiest and the safest way is to pick it up at the stylo-mastoid foramen since the distal end should always be uncovered completely. (Beginning at this stage of the operation, and until its completion some type of magnifying glasses should be used. With them less injury will be done to the nerve when uncovering it, more details of the injury will be observed and, during grafting better apposition can be obtained.)

The roof and sides of the fallopian canal are now removed if possible up to and beyond the site of the injury, of course, if the nerve has been injured up to the geniculate ganglion it is impossible to go any farther. The nerve is inspected and, if a piece is missing, one must choose between two procedures—a nerve graft or a rerouting of the nerve. Rerouting of a nerve means its removal from its bed in order to shorten the distance between the proximal and distal ends; in other words, it is an end-to-end anastomosis. I prefer the graft operation for the reason that, in removing the nerve from its blood sheath, the nerve ends are detached. There must necessarily be a change in its course and the granulations which are the result of the injury to the graft when I have grafted

the nerve instead of rerouting it.

**Grafting the Nerve.**—After the nerve has been uncovered from the stylo-mastoid foramen to the site of the injury in the distal end, and

healthy nerve has been encountered in the proximal end, the torn nerve ends are cut off squarely above and below the injury. If the nerve has been severed for about three months there will be a clubbing of the proximal end. This clubbing, or neuroma, is the result of neurons growing down from the brain which, after finding nothing to which to attach themselves have a tendency to turn and go back, thus forming a neuroma. This neuroma must be excised. The sheath is then slit over the entire exposed nerve, the dehiscence is measured in millimeters and a piece of fresh nerve is taken from some nerve in the body (I use the anterior femoral cutaneous nerve—a branch of the crural nerve). This piece of fresh nerve is fitted snugly between the severed ends making certain that the graft is several millimeters longer than the dehiscence because, if it is too short, one has trouble when trying to relocate the severed nerve. If trouble is encountered when trying to locate this or any other nerve—and it may occasionally occur—several small strands of nerve may be used for the graft, i.e., a cable graft. A nerve larger than the facial nerve is never used because with a larger nerve there is more danger of necrosis, thus defeating the desired results. My experience with the cable graft in a number of cases suggests that it may be the best to use. In using one nerve or several strands one must make certain that the ends fit snugly and that no blood clot intervenes between the two ends.

There are three methods of repairing the facial nerve.

That is just as good—or far better—than any artificial glue one can make. Ordinarily, sutures are not used to hold the ends together for two reasons: first, the graft is in a trough that is formed by the bottom of the fallopian canal which is immovable, and, second, sutures tend to form scar tissue which helps to retard the growth of the neurons. However, if the graft is done in soft tissue then it is necessary to fix the ends with a suture or, preferably, a fibrous glue. If a small strand of nerve is left between the injured ends—and especially if there is a slight voluntary motion in any part of the face—the strand must not be cut out. A fresh piece of nerve is tucked in beside it between the damaged ends of the nerve.

A piece of gold leaf is now laid over the entire exposed nerve. Although this is not absolutely necessary, it tends to hold the graft in place and it keeps the packing from sticking to the nerve. Narrow strips of packing gauze moistened in saline solution are packed lightly into the wound. I do not advocate the use of strong antiseptics in the wound because I believe them to be detrimental to the graft. If the grafting follows a simple mastoidectomy, the dressing is changed as often as necessary to keep the wound clean. At the end of a week

newly formed auditory canal. This dressing is also changed as re-

has formed in the nerve sheath or the sheath and a few strands of the nerve have been cut, then it is necessary only to slit the sheath not neces-  
is treated  
packing is  
used. It must be laid tightly into the wound so as to put any pressure on the exposed nerve.

#### FACIAL PARALYSIS OF TOXIC ORIGIN

**Preoperative Paralysis**—Facial paralysis that accompanies acute otitis, acute mastoiditis and chronic mastoiditis or the so-called "Bells"—or refrigeration—palsy is usually due to an edema resulting from a toxic neuritis. Acute otitis media accompanied by facial paralysis is in itself no indication for an immediate operation unless there is a quick loss to faradic stimulation and indications of a mastoid involvement. These are the cases that should undergo a simple mastoidectomy only without decompression of the facial nerve. If however the paralysis persists and shows no improvement over a period of from six weeks to two months then one is justified in decompressing

diately. Uncovering the nerve in all of these cases is a debatable question. I have seen many of the cases clear up following a radical mastoidectomy especially those in which no fistula or signs of an osteitis could be observed in the fallopian canal however if these

partially decompressed as has been advocated by some surgeons

"Bell's Palsy"—Recovery occurs spontaneously in 85 to 90 per cent of the cases of Bell's Palsy while in 10 to 15 per cent it does

not—or is only partial. The latter cases should have the benefit of surgery. No known medicine such as prostigmine, vitamin B, or potassium iodide has been of value in my experience although one may be justified in prescribing such medication as a placebo. Least likely to clear up spontaneously are those cases in which considerable pain is felt over the temporal, the zygomatic or the postauricular regions. In all cases of Bell's palsy I rely to a great extent on the response to faradic stimulation. If a response is obtained the paralysis will clear spontaneously. If the response is lost the paralysis is not likely to subside or will clear only partially. In any case in which response is lost and the angle of the mouth is drooping when in repose, a decompression operation should be done after a period of six weeks of waiting.

**Operation**—The usual postauricular incision is made as for a mastoidectomy, the periosteum is retracted, the cortex removed and the cells are cleaned out over the descending portion of the fallopian canal (a complete mastoidectomy is not performed), the tip of the mastoid bone is bitten off and the nerve exposed at the stylomastoid foramen, it is uncovered up to the horizontal semicircular canal, the sheath is slit and the wound completely closed. If this operation is to prove successful, it should be performed within a period of from four to five months after the onset of the paralysis, the results of operations performed by me at a later date have been very discouraging.

#### CONTRAINDICATIONS TO REPAIR

Cases not suitable for a direct line repair, end to end anastomosis or any of the former anastomotic operations are those in which the response to galvanic stimulation is lost. This may cover a period of several years. Such loss indicates that the muscles have atrophied or become fibrosed making an operation fruitless (my results have been negative) although Sullivan<sup>2</sup> reported a case of fourteen years' standing in which cure was obtained by means of a nerve graft. The  
 hents is the inability to close the  
 wind or when exposed to strong  
 amatic conjunctivitis but I have  
 seen only one patient who developed an ulcer of the cornea

#### RETURN OF FUNCTION

Best results are obtained in cases in which a decompression is all that is necessary. Voluntary motion starts to return within a period of three to six months. Where a graft operation is necessary, it takes from six to nine months for voluntary motion to start to return, in fact, I have seen a few cases in which signs of return of motion did not appear for a period of fourteen months. This voluntary motion

will first be noticed in the corner of the mouth and it can be brought

motion will always be very gradual. The function of the frontalis muscle will practically never return, therefore the patient will not be able to wrinkle the forehead on the paralyzed side. (However, I have four cases in which the frontalis muscle does function.) Why this function practically never returns I do not know although one explanation is that the fewer contractile elements present in the frontalis muscle degenerate before innervation has been established (Martin).<sup>3</sup> A slight associated movement will always be noticeable, especially when the patient attempts to wink and close the eyes tightly. This is probably due to a splitting of the neurons that takes place during the regeneration of the nerve. Elevation of the upper lip will not be as good on the paralyzed as on the nonparalyzed side and, when the patient smiles, the teeth are more prominently displayed on the nonparalyzed side. Very often a slight twitch will be observed for the first few years and this will be aggravated by the patient's self-consciousness.

#### A FEW OBSERVATIONS

While the classical signs and symptoms of facial paralysis are not mentioned in this paper, there are two signs to which I would like to draw attention. First, all patients with complete facial paralysis can move the upper eyelid. Even in a case in which the nerve was gone from the geniculate ganglion to the parotid gland, I have observed that the eyelid still moved. It is the lower eyelid that does not move. Second, there is only one way to determine whether a patient while under an anesthetic has a facial paralysis and that is to detect movement of the alae nasi muscle on one side and not on the other.

In my series of cases in which paralysis followed a simple mastoidectomy, I found most often that the operator had gone too low in searching for the antrum and had made one just below the horizontal semicircular canal, thus severing the facial nerve. In other cases the nerve had been injured in probing the antrum or in enlarging it and attempting to curet granulations from its floor, and when cureting the retrofacial cells that often open into the descending portion of the fallopian canal or go under it. Where the paralysis followed a radical mastoidectomy the nerve was usually injured on the floor of the antrum where the bone covering the nerve as it crosses the middle ear is very thin. In others it was injured at the apex of the facial ridge when shaving down the bone where often there is a dehiscence in the canal which may be covered with granulations,

these granulations should always be inspected carefully and removed with the greatest of caution if this accident is to be avoided

### AFTER TREATMENT

Some form of support should be used to hold up the sagging muscles strapping up the paralyzed side by means of adhesive plaster or Scotch tape or using a hook in the corner of the mouth. I prefer the hook because as the patient desires it can be removed and replaced it does not irritate the skin as does the adhesive plaster or Scotch tape. Some form of massage is advisable preferably with a galvanic machine for it helps to prevent atrophy of the muscles is physically stimulating and boosts the patient's morale. Patients are prone to place great faith in the curative powers of some form of electrotherapy.

*Reeducation* is of great importance. By sitting in front of a mirror the patient can practice smiling, laughing and talking to himself with particular emphasis on the paralyzed side this practice will help him regain more symmetry of facial expression.

### SUMMARY

The face will never be as symmetrical as before the onset of the paralysis but if the operation is performed shortly after the onset, there should be about 90 per cent return of function. There are times when the patient's face will not look as well as it does at other times exposure to cold and fatigue are often responsible for this. A photograph should be taken of the patient smiling and with the eyes closed before and after the operation. Years later when patients return regretful that the postoperative result is not more perfect it is helpful in improving their outlook to have the photographs as proof of how grotesque was their appearance at the onset of the paralysis.

The return of function will always be gradual regardless of which operation is performed. Ninety per cent of all operations should be successful when the injury is found to be in the fallopian canal if the operation is performed with meticulous care and shortly after the accident.

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## PERIPHERAL NERVE INJURIES

### Some Recent Progress in Treatment

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#### INTRODUCTION

THE major part of our knowledge of peripheral nerve surgery has been acquired during the past thirty years and interest has waxed and waned largely as the result of the two major wars which have occurred during this period. Previous to the war of 1914-1918 there was but little helpful literature, the outstanding contributions being Weir Mitchell's *Injuries of Nerves and their Consequences* (1872), and Sherren's monograph published in 1908 as a result of his work with Head. The latter postulated his theory on cutaneous sensation which has since proved untenable. Viewed broadly, peripheral nerve surgery was a new and largely unexplored field. There was little authentic information available and still less knowledge of what was to be expected in the way of end results.

As the result of the 1914-18 war, valuable lessons were learned. Many procedures were tried such as neuroplasty (the turning down of a flap from the proximal to the distal stump) or the joining of divided ends by a sheath of fascia or vein graft, only to be discarded as impracticable.

End-to-end suture was established as the only effective means of producing reinnervation. The preoperative and postoperative treatments and the treatment of the lesion recovering without operation were systematized, and the importance of preserving joint mobility, especially that of the smaller joints of the hand and foot, became apparent.

It is unfortunate that so much material which became available during the first World War, and from which so much was learned, should have been allowed to disappear without the most having been made of it. Two difficulties are apparent. Firstly, there was no standard method of recording the progress of the lesion. Secondly, the available statistics were somewhat meager and there is no statistical record of the vast numbers of patients who were operated on. No late follow up showing true end results on a large scale was possible.

In the late war these two major deficiencies were overcome. In the United States, the Peripheral Nerve Registry was established by the Surgeon General in 1944, and Woodall and Lyon recorded in 1946 that over 7000 cases had already been reported. In the United King-

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with the cooperation of the Ministry of Health, an efficient follow up system which the M.R.C. has laid down certain criteria for sensory and motor recovery which are used in all peripheral nerve centers so that the records may conform to a set standard. These criteria are

#### *Assessment of Sensory Recovery*

- S0 Absence of sensibility in the autonomous zone
- S1 Recovery of deep cutaneous pain sensibility within the autonomous zone of the nerve
- S2 Return of some degree of cutaneous pain and touch sensibility within the autonomous zone of the nerve
- S3 Return of superficial cutaneous pain and touch sensibility within the autonomous zone of the nerve
- S4 Return of sensibility as in stage 3 with the addition that there is recovery of 2 point discrimination within the autonomous zone

#### *Assessment of Motor Recovery*

- M0 No contraction
- M1 Return of perceptible contraction of the proximal muscles
- M2 Return of perceptible contraction in both proximal and distal muscles
- M3 Return of function in both proximal and distal muscles to such an extent that all important muscles are of sufficient power to act against resistance
- M4 Return of function as in stage 3 but with the addition that all synergic and isolated movements are possible
- M5 Complete recovery

It is estimated by Spurling and Woodall that there were 2500 peripheral nerve injuries occurring in the Second World War forming 10.5 per cent of battle casualties. For this reason it is often thought that peripheral nerve surgery is of importance only in war and plays only a small part in civilian practice. However, with the frequent accidents occurring in industry and on the roads the number of peacetime injuries is mounting. Bristow illustrates this with figures from two nerve centers in the United Kingdom

Jan 1st 1941 to Dec 31st 1946	
Gunshot wounds	2196
Accidental damage motor cycle etc	159
Fracture or dislocation	151
Laceration	130
Total	2636

In addition injuries to digital nerves are becoming increasingly frequent and their repair is being more often attempted thanks to the

## PERIPHERAL NERVE INJURIES

### Some Recent Progress in Treatment

P. G. SOMERVILLE, M.B., F.R.C.S. (Eng.)\*

#### INTRODUCTION

THE major part of our knowledge of peripheral nerve surgery has been acquired during the past thirty years and interest has waxed and waned largely as the result of the two major wars which have occurred during this period. Previous to the war of 1914-1918 there was but little helpful literature, the outstanding contributions being Weir Mitchell's *Injuries of Nerves and their Consequences* (1872), and Sherren's monograph published in 1908 as a result of his work with Head. The latter postulated his theory on cutaneous sensation which has since proved untenable. Viewed broadly, peripheral nerve surgery was a new and largely unexplored field. There was little authentic information available and still less knowledge of what was to be expected in the way of end results.

As the result of the 1914-18 war, valuable lessons were learned. Many procedures were tried such as neuroplasty (the turning down of a flap from the proximal to the distal stump) or the joining of divided ends by a sheath of fascia or vein graft, only to be discarded as impracticable.

End-to-end suture was established as the only effective means of producing reinnervation. The preoperative and postoperative treatments and the treatment of the lesion recovering without operation were systematized, and the importance of preserving joint mobility, especially that of the smaller joints of the hand and foot, became apparent.

It is unfortunate that so much material which became available during the first World War, and from which so much was learned should have been allowed to disappear without the most having been made of it. Two difficulties are apparent. Firstly, there was no standard method of recording the progress of the lesion. Secondly, the available statistics were somewhat meager and there is no statistical record of the vast numbers of patients who were operated on. No late

that over 7000 cases had already been reported. In the United King

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others have shown that the poor results after secondary suture are due to shrinkage of the neurilemma tubes in the peripheral segment which delays the maturation of the downgrowing axons. Gutmann and Young (1944) found that with delay there is progressive atrophy in the muscle fibers and end plates so that the new axons returning after some months are unable to reenter the old nerve ending. In this way muscle fibers become completely wasted and useless.

**Primary and Early Secondary Suture.**—Speculation still persists, however, about the relative merits of primary and early secondary suture and the latter appears to have certain points in its favor. A short interval following injury produces a thickening of the nerve sheath making for easier technique and a firmer suture line. Young (1942) has found evidence the degeneration of the nerve fibers in the distal stump causes activation of the Schwann cells which reaches its peak between the nineteenth and the twenty fifth day. Since these cells appear to play such an active part in the junction of a severed nerve, a short delay of 10 to 20 days would seem to be beneficial.

In 1946 Zachary and Holmes analyzed fifty five primary nerve sutures in forty nine patients. In three the nerve was accidentally divided at operation, fourteen nerves were sutured during the primary treatment of gunshot wounds and thirty eight during the repair of incised or lacerated wounds. The results were compared with a series of secondary sutures and the conclusions drawn were that there was a higher proportion of poor recoveries and a lower proportion of good recoveries in the series of primary suture.

The main adverse factor for primary suture with particular reference to gunshot wounds is the difficulty in knowing how much nerve to resect before healthy bundles are reached. In war wounds the local damage to the nerve ends is likely to be more extensive, compared with simple laceration, and the chances of performing an adequate excision of damaged nerve trunk and accurate epineural suture are not so good. An early secondary operation is more reliable. Primary approximation of the nerve ends may be performed or, alternatively, they may be buried in neighboring muscle. With adequate wound surgery and the latest adjuncts to prevent sepsis, the secondary operation should be possible within a few weeks or at the most a few months. During the late war both British and American surgeons aimed at early secondary intervention.

Spurling and Woodall have published a preliminary report on nerve operations carried out in American hospitals in the United Kingdom, from the invasion of Europe until V-E Day. There were roughly 1500 nerve sutures performed with a delay of thirty eight days at the beginning, rising later to forty two. Among eighty nine primary sutures there were twenty failures—a rate of 22 per cent, which is distinctly higher than their figure of 5 per cent for the series of early secondary

work of Stirling Bunnell Unless these are repaired at the time of injury subsequent attempts may prove much more difficult

## TECHNIC

**Suturing Materials and Methods.**—Few new important features in technic have come to light as a result of the recent war. Suture of the sheath only is in general practice with occasional advocates of a stay suture. A suture line free from tension is essential, but a stay suture rarely appears necessary and may help to increase the fibrosis. The suture materials in general use are those which are known to produce the least reaction, such as the finest silk or stainless steel wire, while tantalum is popular, particularly in America. An additional advantage of the latter two is that radiography may help to prove disruption of the nerve ends in some cases that fail to recover function.

Protection of the suture line was first practiced in the 1914-18 war but was soon given up as being of doubtful value. However, during the late war a return was made to it by some American surgeons, using tantalum foil. No use was made of this by British surgeons as their experience showed that any form of wrapping was liable to increase the fibrosis.

In 1940 Medawar and Young, as the result of experiments on animals, put forward the idea that coagulated plasma was an effective method of uniting nerve ends. Fibrinogen plasma (glue) is an ideal material for uniting two or three lengths of a small nerve into the so-called cable graft for bridging a gap but for end to-end suture it does not appear to have improved results.

Careful and accurate suture is one of the most important details and every effort should be made to suture the ends of the nerve in their correct alignment. In order to prevent rotation of the nerve during suture fine silk knots may be placed in the epineurium in the same plane above and below the level of the lesion before the nerve is disturbed from its bed. The appearance of the nerve ends should be carefully inspected for corresponding blood vessels in either segment. Because of the rapidly changing topography of the nerve trunk, torsion of the nerve segments is of less importance when a considerable gap exists before suture.

**Early vs. Late Repair.**—Nerve injuries are usually plainly evident, but it must be remembered that with the syndrome of complete division and a wound in the anatomical line of the nerve, exploration

if these fail to appear

It has been proved conclusively that delayed suture produces poor clinical results. Thus, Holmes and Young (1942), Sanders (1942) and

tant Apart from the loss of time which is involved in awaiting union the all important consideration of overcoming a nerve gap can be relatively easily solved in the presence of a fracture compared with the more formidable procedure of shortening an intact femur or humerus before proceeding to nerve suture

**Transposition**—In the case of the ulnar nerve added length may be obtained by transposition to the front of the elbow joint and a similar procedure though less frequently required may be carried out for the radial nerve by rerouting it through the muscles in front of the humerus

**Nerve Grafting**—When a gap exists which cannot be overcome by one of these length producing procedures the outlook is poor but a nerve grafting operation may be tried Of various methods heterografts have never proved of the slightest value

**Homografts**—Either fresh or stored homografts have proved a success in restoring function in a variety of animals especially the cat and the rabbit In man out of a total of forty two cases reviewed by Sanders (1942) only three cases of recovery survived careful scrutiny These three were from a series of six homografts of the facial nerve by Duel (1933) In these cases the gap was quite short and the size of the gap was small

In 1944 Seddon and Holmes reported four cases of homografting in man All were failures and in three the grafts were examined 371 425 and 573 days later Two fresh grafts had become collagenous to such an extent that almost nothing remained of the original nerve elements and there was no possibility of recovery The third and stored graft was quite dead and in the process of phagocytosis

The possible causes of failure suggested by Seddon and Holmes are (a) incompatible blood group an unproved and improbable factor (b) the development of a specific tissue immunity such as seems responsible for the destruction of skin homografts (Medawar 1945) Where the gap is short as in animal experiments the reaction may not occur until after the fibers have reached the peripheral stump But in man the gap is long and it may be that the reaction attains its maximum before the fibers have transversed the graft and (c) failure of vascularization which is almost certainly of no significance

Since 1944 eight cases have been reported by Barnes and his co-workers all were complete failures On examination between 104 and 904 days from insertion partial innervation from the proximal stump could be seen with complete fibrosis in the distal part of the graft The histologic appearance after 904 days suggests that ultimately there is total replacement of the graft by the tissues of the host

Barnes and his associates agree with Seddon and Holmes that inadequate vascularization is not a satisfactory explanation for only partial reinnervation of homografts and accept tentatively the sug

sutures. The follow up period has necessarily been short, but the final statistics should prove of the utmost value.

While early secondary suture has established itself as the method of choice in war surgery, primary suture would still appear to have its place in many civilian injuries. In the repair of digital nerves, an important and fairly common operation in civil practice, primary suture will offer the surgeon his one chance of effecting direct repair. The freeing and suturing of a divided digital nerve in scar tissue following healing is generally impossible.

Section of a nerve by a clean cut and division of a nerve accidentally at operation would also appear to be treated best by primary suture.

**Neurolisis**—When loss of nerve function follows contusion without an open wound, it is difficult to assess the degree of injury and the surgeon may, because of the hope of spontaneous recovery, lose the opportunity for early repair. In the absence of any evidence of recovery, the nerve should be explored at the end of three months.

The operation of neurolisis or the freeing of the nerve from scar tissue is the usual accompaniment of any nerve exploration which does not end in suture. In the majority of cases the operation makes no difference to recovery but is of value when traction is exerted on a

the site of suture. In most cases the gap so produced will be small enough to be of no consequence. As the amount of resection increases, various methods of technic are employed, such as wide mobilization, stripping of branches and posturization of the limb in order to allow for end-to-end suture. If however the gap is likely to be too great for sutures in spite of these adjuvants then bulb suture as a temporary expedient may be tried.

**Bulb Suture.**—Doubts have been expressed about this two stage procedure (Leriche 1940, Stookey, 1922), on the grounds that post operative stretching may cause intraneural hemorrhages followed by subsequent scar formation and sclerosis. These doubts are further substantiated by the poor results achieved following traction injuries such as occur in the lateral popliteal. However, a number of cases—although few in number—described by Bristow from two peripheral nerve centers, have shown results comparable to end-to-end suture. The difficulty arises in those cases in which it is difficult to say how far the nerve ends are reached. But in such cases unless one is certain

**Bone Shortening**—In those cases where there is both a fracture and a nerve lesion it is wiser to regard the nerve as the more impor-

double back upon themselves and some will escape at the suture line.

A sensory motor fiber will grow down any Schwann tube that it meets but if a motor fiber has gone astray it will make no connection with a sensory nerve ending. Similarly, a sensory fiber will make no connection with a motor end plate. Hence a mixed nerve like the ulnar has much less chance of complete success than a nerve like the radial.

The internal anatomy of nerve trunks has been worked out in considerable detail beginning with the work of Stoffel (1912) down to the recent work of Sunderland (Brain, 1945) and there is no doubt that great changes take place in the topography of nerve fibers, the so called internal plexuses. The importance of preventing rotation is perhaps greatest in those cases where there is no loss of nerve, and is of less importance where a nerve portion has been excised. Regeneration after anatomical division of the facial trunk is invariably followed by mass movements. The best explanation of this is that straying of regenerating fibers binds the muscles of expression into a functional unit incapable of dissociation, so essential to emotional expression.

Again in certain types of nerve injury we may be forced to suture the nerve ends. In this case the collagen formation would be either central or peripheral and this collagen formation forms an impenetrable barrier, preventing the axons gaining entrance to the Schwann tubes.

In this connection, apart from accurate note-taking and description of the operation, if microphotographs of the resected nerve ends are filed with the notes they may prove to be of the utmost value for reference during the follow up period.

**Radial Nerve.**—The suture of this nerve heads the list of nerve recoveries, depending as it does almost entirely on motor function of a coarse nature. In those in which repair is found impossible, tendon transplantation as originally described by Sir Robert Jones gives a useful hand with extension of the wrist and fingers. Zachary (1946) pointed out that the results are improved if one wrist flexor is left in situ to fix the wrist.

**Median Nerve.**—From the point of view of function, recovery of sensation in the median nerve is all important. Rather more than half of the patients with high or low lesions recover up to the point of having a safe hand. That is to say, pain can be appreciated, thereby avoiding injuries and burns. A divided median nerve will almost certainly leave some degree of permanent disablement which may well be severe in a few cases.

**Ulnar Nerve.**—A divided ulnar nerve is a less severe handicap to the majority than a divided median. The resulting disability will de-



gestion that the length of the graft traversed by axons is an index of the latent period during which the host acquires its active immunity

**Autografts**—The results obtained in man have been much more encouraging. Both fresh and predegenerated grafts are being used (Duel, 1933, Bunnell, 1939, Collier, 1940, Seddon, 1946). Predegeneration produces a graft of firmer consistency and is, therefore, easier to handle.

The method used by Duel for the facial nerve was to section the anterior femoral cutaneous nerve proximally and distally and to leave it undisturbed for two to three weeks. He claimed that not only was it easier to handle but regeneration occurred at a quicker rate. Since that time the rate of recovery of function has been investigated for fresh and predegenerated grafts (Lathrop, 1946) without observing any difference.

The difficulty of obtaining a graft of comparable size to the proximal stump frequently arises. A graft may be taken from the least important nerve in a case in which two nerves are injured producing large gaps such as the median and ulnar nerves. Alternatively, where a nerve injury exists with an amputation a satisfactory graft may be obtained. If either of these methods is not available resort may be had to the so called cable graft consisting of strands of small and unimportant superficial nerves such as the sural, anterior femoral cutaneous or intercostal nerves. For the purpose of fixing these grafts together and in position fibrinogen plasma (glue) has been found most effective.

Recent results represented at the XLIX Congres Francais Chirurgie, Paris, Oct. 1946 from the Oxford nerve center, prove encouraging. Out of a total of fifty eight cases including cutaneous cable and thick grafts twenty four were described as cures, five as partial cures and thirteen as being of too recent operation for assessment.

#### SOME REASONS FOR FAILURE

It is worth remembering that the final result as far as the patient is concerned is often better than at first anticipated. In other words the neurological recovery often falls short of functional recovery. However the ultimate prognosis of nerve injuries will depend upon many factors and a review of the pathology of regeneration of a di-

infection some axons will fail to reach their objective. A certain number will find their way between the Schwann tubes while others will

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pend upon the patient's occupation. Full and heavy manual work can be carried on in many cases but those requiring precise and delicate movements are seriously handicapped. Full neurologic recovery is not seen although restoration of voluntary power in the interossei may occur with accurate suture at the wrist in children.

**Sciatic Nerve**—The neurologic results following suture are none too good. The proximal muscles may recover satisfactorily but the small muscles of the foot never. The recovery of sensation in the sole is poor also and may lead to traumatic ulceration. Bristow states that suture of both divisions of the sciatic nerve produces results as good as suture of one element alone. In a series of thirty-three sciatic nerve sutures 33 per cent of the patients showed after one year contractions of the proximal muscles against resistance combined with a return of some degree of cutaneous pain and sensibility on the sole.

### CONCLUSION

Our knowledge resulting from the great quantity of material of the recent war will not be complete for some years until the follow-ups have been completed and analyzed.

Criteria suggested by the Medical Research Council for the recording of both recovery and motor function in nerve injuries have been presented. For the correlation of results from various sources it is important to have a common basis for comparison.

Few new important technical advancements have been made as a result of the second World War but evidence is presented that early secondary nerve suture has certain advantages over primary suture particularly in gunshot wounds.

Whereas direct end-to-end suture gives the most satisfactory results the treatment of a nerve gap not amenable to this method is reviewed. The two-stage operation with bulb suture can lead to better results than might be expected from a study of traction nerve injuries.

Our knowledge of nerve grafting is increasing slowly. Homografts

sometimes difficult to find

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one of the first structures in the body to degenerate with age and usage, and Beadle, one of his pupils, described in a classic monograph the various types of changes which occur

# PATHOGENESIS

In order to arrive at a workable concept in regard to lesions of the intervertebral disk, it is necessary to categorize the pathological findings in morbid specimens, such as described by Beadle, and those seen at the operating table. The role played by trauma or strain in the production of disk lesions is accepted, but the underlying factor, that is, the inherent degenerative process due to premature aging must not be overlooked.

Ordinarily the first change to occur is a fibrillary degeneration and fragmentation of the inner cartilaginous rings so that these structures no longer play their part in maintaining separation of the vertebral bodies. Collapse of the disk is only prevented by the containing capsule which does not allow the escape of disk material. At this point the disk capsule is under considerably increased tension and tends to bulge circumferentially throughout its entire surface. Stresses and strains during this stage of the disease are apt to cause tearing of the fibrous elements of the capsule, producing a clinical picture similar to that seen in sprains of other joints, i.e., pain on motion with spasm of supporting musculature (Type I). This state may persist for considerable time, eventually to be associated with hypertrophic changes in the margin of the adjacent vertebral borders or within the disk capsule itself. It must be postulated that the low grade inflammatory process which brings about these secondary changes of fibrosis and calcification succeeds, in many instances, in fortifying the disk capsule, preventing its rupture and the escape of the disk contents.

Following the first stage of disk softening with distention of the disk capsule, the capsule itself may bulge locally and eventually give way with a protrusion of disk material. When actual rupture of the annulus fibrosus occurs, the fragmented portion of the disk may escape completely into the extradural space allowing collapse of the disk. It is more common, however, for the head of the sequestration to protrude leaving the tail within the disk space (Type II A). Since the joint capsule is relatively thin over its posterior aspect, these protrusions are most apt to occur in the region of the neural canal. The posterior longitudinal ligament, however, reinforces the midline and tends to

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laminarum havum to make its exit through the foramen of the segment below. With an extreme lateral herniation, the nerve roots of the same segment may be impinged upon.

# LESIONS OF THE INTERVERTEBRAL DISKS

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RECENT increase in knowledge of the intervertebral disk and the pathologic changes which affect it make it more and more apparent that many of the poorly defined disorders of the spine are due to lesions of this structure

Most of the literature on the subject is devoted to the so-called "herniation of the disk" but it must be realized that a sequence of pathological events takes place within the disk which may or may not end in sequestration and herniation of disk material

## ANATOMY

The normal disk is a fibrocartilaginous structure interposed between the adjacent vertebral bodies. The fundamental characteristic of this disk is its elastic turgidity—that quality by which it maintains separation of the vertebral bodies in weight bearing at the same time permitting a limited amount of flexibility. It varies in size, shape and thickness at different levels, being thickest in the cervical and lumbar regions to allow a greater degree of motion. The disk itself is composed of concentric laminae of fibrocartilage, denser and more fibrous in the outer laminations and centrally blending with the notocordal remnant, the nucleus pulposus. The outer fibrous rings form the capsule, the annulus fibrosus, which is closely connected with and reinforced by the anterior and posterior longitudinal ligaments. A thin layer of hyaline cartilage attaches the disk firmly to the adjacent vertebral bodies.

Generally considered to be avascular, blood vessels within the disk have been found by some investigators up to the age of 25 years<sup>1</sup> and nutritive canals have been described which communicated directly with blood vessels of the spongiosa of the vertebral bodies.<sup>2</sup> There

be readily demonstrated a ... it under local anesthesia. It has been pointed out by Schmorl that the disk is

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occasionally the sequestration blocks the entire canal with resulting From syndrome

If unrelieved by surgery scarification occurs which involves both the sequestrum and adjacent nerve roots Calcium may be deposited as the osteoarthritic process continues (Type III)

In an indefinite percentage of cases the disk capsule remains intact but the degenerative changes continue within until the internal architecture of the disk is completely lost On weight bearing this type of disk collapses to such an extent that not only the nerve roots but the dural tube itself may be compressed At operation with the patient in the prone or lateral position these disks may appear normal but detection of the lesion is easily accomplished by the method described in the "operative procedure"

We have attempted to classify at the operating table four grades or types of pathological specimens (Fig 138)

- Type I Softening of the disk structure with distention of intact capsule
- Type II
  - A Rupture of the capsule and extrusion of disk material beneath the longitudinal ligament or into the epidural space
  - B Completely degenerated nucleus and inner laminae with intact annulus fibrosus
- Type III Fibrous and calcification associated with hypertrophic changes of adjacent vertebral bodies

To understand the symptomatology of disk disease it is essential to keep in mind the pathological sequences described above

### CLINICAL FINDINGS

Over 400 operations for herniated disks have been carried out in this hospital in the past four years A careful study of the last 150 cases operated upon is presented in order to correlate the clinical and operative findings The operative technic described below was used in practically all cases Herniations were found in 134 of those operated upon leaving a diagnostic or operative error of 10.7 per cent It is now felt that some of the negative explorations were in reality Type II B disks that were not clearly understood at the time of the earlier explorations

Of most importance in the anamnesis is the complaint of low back ache with a unilateral sciatic pain worse on coughing and sneezing showing a certain intermittency of symptoms and a tendency toward recurring acute attacks A decrease in the backache with the development of sciatica appears to be pathognomonic of a herniated disk Difficulty in sleeping in a soft bed is usually noted

The most reliable diagnostic signs are positive hyperextension test, point tenderness on paraspinal pressure over the exiting nerve root radiating typical pain, and a flattened back with a list usually away

Symptomatology and clinical findings vary with the location of the sequestration, not necessarily with the size. Following rupture of the annulus the pressure within the disk itself is relieved and stimulation of nerve endings in the longitudinal ligament decreases thus the back



ache frequently decreases with the onset of root pain. The vertebral list which had been away from the bulging side occasionally shifts to the now freshly collapsed side. The hyperextension test remains positive. If there is an increase in the spinal fluid protein below the lesion at this time it is due to an inflammatory change in the nerve root.

in determining both the presence and location of the lesion.<sup>5</sup> Associated bony abnormalities such as sacralization lumbarization, unusual facets or osteoarthritic changes are commonly found along with pathological disks.

An analysis of clinical findings is given in Table 1

### OPERATIVE PROCEDURE

The patient is placed on the operating table in the lateral position the side to be operated upon uppermost (Fig 139) Spinal anesthesia

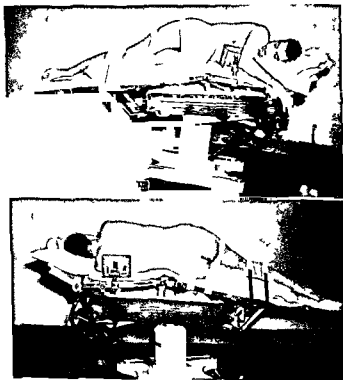


Fig 139—The lateral position for intervertebral disk exploration

is preferred but either local or general anesthesia may be used. The under leg is flexed to 90 degrees. The upper leg is extended. A small pillow is placed between the thighs. The kidney rest is elevated 3 inches and is placed about 1 inch cephalad to the iliac crest. The patient is held in position with wide bands of adhesive plaster, being careful to protect the peroneal nerve of the under leg with padding.



from the side of the lesion Reflex, motor and sensory findings are recognized as evidence of advanced nerve root damage but are not considered essential to the diagnosis of disk disease

TABLE 1

PERCENTAGE OF CASES PRESENTING POSITIVE FINDINGS IN 150  
CONSECUTIVE DISK EXPLORATIONS

Symptoms	134 Proven Disk Lesions	16 Negative Explorations
Low backache	97%	73%
Intermittent symptoms	97%	69%
Pain down sciatic distribution on coughing, sneezing etc	93%	57%
Unilateral sciatic pain	90%	55%
Recurrence of acute episodes	86%	33%
Decrease in backache when sciatic pain develops	78%	0%
Increase of pain at night when sleeping in soft bed	78%	50%
History of trauma	77%	88%
Weakness in legs	33%	34%
Bilateral sciatic pain	10%	14%
Sphincteric difficulties	4%	0%
Signs		
Positive extension tests	95%	62%
Flattened lumbar curve	92%	68%
Paraspinous pressure test	89%	50%
Positive straight leg raising tests	87%	100%
List away from the affected side	81%	66%
Reflex changes	76%	26%
Sensory disturbances	75%	87%
Obvious motor weakness	33%	34%
Frank kyphosis	12%	0%
List toward the affected side	8%	8%
X-ray findings		
Flattened lumbar curve	92%	68%
Positive lateral bending films	73%	11%
Narrowed disk interspace	42%	30%
Associated bony abnormalities	46%	75%
31 cases operated upon had preoperative pantopaque myelograms		
5 cases with myelographic defects and negative explorations		
4 cases with normal myelograms and positive explorations		
22 cases in which the myelograms corresponded to operative findings		
Myelographic error—30%		

X ray study is made largely to rule out other pathological conditions Again a flattened lumbar curve is nearly always present A narrowed interspace is usually indicative of disk disease but it is absent in nearly 60 per cent of the cases Lateral bending films are of value

this handle is then gently forced into the epidural space. A cotton pattie on a string is then inserted to hold back the dura and nerve root while a window is cut in the ligamentum flavum. This may then be safely enlarged with the nasal punch. One pattie on a string is gently pushed cephalad in the canal and one caudad. These act both as dural retractors, and in maintaining hemostasis. The nerve root is teased medially with a blunt dental instrument, retracted with a nerve hook and the disk capsule exposed. The protrusion or extrusion, if present, is then removed with the pituitary forceps, and the forceps may be introduced into the disk space to extract unextruded sequestra. In the case of a Type II B disk no distinct herniation may be seen with the patient in the lateral or prone position.

Should the symptomatology direct suspicion to a relatively normal appearing, but boggy feeling disk, saline is injected into the disk capsule through a fine spinal needle. It is impossible to inject a healthy disk whereas a degenerated disk will readily accept from 5 to 20 cc of saline. Ruptured disks with hidden points of rupture may also be demonstrated in this manner. We believe that it is important in the Type II B disk lesions to remove all the material possible, allowing collapse of the space and increasing the possibility of a strong fibrous repair, however, it is our opinion that the necessity for fusion will arise most frequently in this group. It is very important in all types of disks, as pointed out by Hyndman,<sup>7</sup> to explore the entire region. This may be carried out by palpating with a blunt right angle nerve root dissector across the midline, into the foraminae, and cephalad and caudad to the disk beneath the longitudinal ligament.

Mild epidural bleeding is controlled by suction against large, sloppy wet pledgets. Occasionally it is necessary to cauterize an extradural vein, or to apply a small muscle pledget under the sloppy cotton, removing the latter and leaving the former in position. A chromic "O" suture approximates the lumbosacral fascia to the interspinous ligament. Closure follows with two layers of 4-0 silk.

It is felt that this lateral approach allows for much better exposure and therefore more accurate exploration by opening the interlaminar spaces to their maximum. It is not accompanied by the rise in venous pressure which

There is no poi

sive bleeding a

position. The o

minimum of trauma to patient and operator. The degenerated bulging disk which reveals itself best in the sitting position<sup>8,9</sup> may be easily

The table is broken in the middle to an angle of approximately 145 degrees and is inclined in such a manner that the back remains horizontal. In this position the lower lumbar interlaminal spaces on the uppermost side are greatly widened making removal of bone unnecessary. The operation is performed with the operator seated his assistant on his right and the scrub nurse on the opposite side of the table. Three trays are placed above the patient and included in the drape.

A 2 inch incision is made over the spinous process of the fifth lumbar vertebra. The electric surgical unit is used to coagulate any subcutaneous bleeders and dissect the ligament and muscle from the

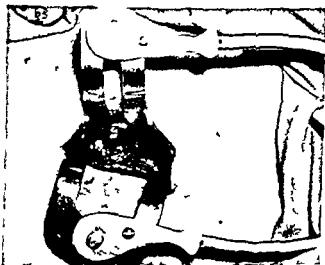


Fig 140—Special automatic retractors for interlaminar approach shown in position

spinous process on the upper side. Subperiosteal dissection with a large sharp periosteal elevator pushing a 2 by 12 inch gauze sponge ahead of it separates the muscles and maintains hemostasis at the same time. Three of these are used one for each lamina. The sponges are removed and the special self retaining retractors inserted (Fig 140).<sup>6</sup> If the skin incision has not been made too long the retractor will stretch the skin sufficiently to control bleeding. At no time during the procedure should hemostatic clamps be necessary. The interlaminar spaces are now exposed with their ligamentous coverings. The fourth and fifth interspaces may be explored from this exposure.

An incision is made longitudinally in the ligamentum flavum with a No. 11 Bard Parker knife blade on a long handle. The blunt end of

tion patients were up and about early. It was noted that approximately 80 per cent of these developed pain in the hips ten days later. weight which er col on was done under local anesthesia it was impossible to elicit any sensation whatsoever by facet stimulation. This was attempted by electrical stimulation by gentle currettement of the articular surface and by saline injection of the facet capsule. Thus it seems that facet pain could be explained only by such a mechanism as that of arthritic capsular swelling pressing against nerve roots described by Ghormley<sup>4</sup> since the faces themselves are not inflamed.

ma fourth lumbar interspace and 8 per cent at both. Eighty eight per cent of the disks were described as Type I or II and 12 per cent were of Type III. Ninety per cent were posterolateral and 10 per cent directly posterior. In the latter the symptomatology was usually bilateral.

Following the sixteen negative explorations 50 per cent of the patients were greatly improved afterwards even though they were informed of the operative findings. Whether decompression by removal of the portion of the ligamentum flavum or the psychic influence of supposedly definitive treatment was responsible is difficult to determine but it is supposed that both factors played a part.

# SUMMARY

1. The pathological sequence of intervertebral disk disease is discussed with emphasis on the degenerative process as the underlying cause.

2. The

k disease is presented ptomatology and clinical

3. The technic of interlaminar exploration with the patient in the lateral position is described.

4. Suggestions are made for the use of these criteria in treatment and prognosis.

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tients were allowed up as soon as they felt fit. Some patients were up and about the day of operation and the majority were ambulatory by the fifth postoperative day. Type I and Type II B patients are kept in bed three weeks and fitted with a low knight back brace and instructed to wear it when up and about for any prolonged period during the first three postoperative months. Some of the latter group have been turned over to the orthopedic service for fusion.

### REMARKS

Pantopaque myelography was done in doubtful cases. This represented thirty-one of those in which operation was done. There were four later proven herniations with negative myelograms and five cases with persistent myelographic defects in which no herniation could be found at exploration.

Spinal fluid protein averaged 53 mg per 100 cc., although 25 per

The long range results of operation in a Type I disk are not enviable. There is usually a sudden dramatic relief of pain but recurrence is likely during the next twelve months because the degenerative process continues with further extrusion of disk material. An attempt is made to treat these patients conservatively, and operation is performed in early cases only when bed rest and back support fail to give relief.

Operation in a Type II A disk is a necessity and should be carried out when such lesion is suspected. The results are usually permanently good. The degenerative process is no longer progressive and the formation of fibrous tissue within the disk cavity is usually adequate to allow

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Fusions were carried out in only two cases. They were done by the orthopedic department. A combined Hibbs Albee type of fusion was performed or a combination of Hibbs type with screwing of the

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With the exception of the above two cases and several in which retraction of the root produced a spinal fluid leak during the opera

# SEGMENTAL ARTERIAL SPASM ASSOCIATED WITH SUPRACONDYLAR FRACTURE OF THE ELBOW

## Report of a Case

A DALE CONSOLE, M.D.\*

SEGMENTAL arterial spasm is a well recognized clinical entity which has been described under several designations including "arterial stupor," "traumatic segmentary inhibition of the arteries," "arterial contusion," and others. It was first described in 1915 by Kroh who reported two cases of temporary occlusion of major arteries of the extremities associated with gunshot wounds. Since that time numerous reports of single cases or small series have appeared, and in 1935 Montgomery and Ireland collected forty two cases from the literature.

regarding its diagnosis and treatment during wartime, it may go unrecognized in civilian practice because of its relatively infrequent occurrence. Since failure to institute proper treatment may result in the loss of a limb which might otherwise be saved, it does not appear amiss to call attention to this phenomenon once again.

## CASE REPORT

J.R., an 8 year old schoolboy, was admitted to the New York Hospital with a compound supracondylar fracture of the elbow on October 14, 1945.

On examination there was the usual deformity associated with this type of fracture. In addition there was a 1 cm. contusion on the medial aspect of the antecubital fossa. The radial pulse was moderately diminished. The skin was entirely satisfactory. The ulnar nerve was intact.

*Course*—Shortly after admission superficial débridement and closure of the wound were performed. Manipulation under anesthesia failed to reduce the fracture and, therefore, a Kirschner wire was inserted through the ulna. After four hours of traction the color and temperature of the fingers remained unchanged and because it was felt that the brachial artery was being compressed, another attempt at closed reduction was made. This resulted in some improvement in

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partial relaxation and complete occlusion by spasm alternated rhythmically at about one to three minute intervals

The brachial artery was dissected out of its bed for a distance of 5 to 6 cm proximal to the point of contact with the bone and after this maneuver could easily be lifted free of it. This failed to produce any change in its caliber or the pulse and it was noted that the spasm extended proximally beyond the highest point of exposure. The fracture was reduced the fragments falling into almost perfect anatomic alignment and this too failed to produce any change in the spasm.

The wound was closed and with the patient still under anesthesia a paravertebral sympathetic block was done posteriorly at the first



Fig 142—X rays of elbow eleven months after operation.

thoracic interspace with 2 per cent procaine. Prior to this the hand and pulse showed no change from the preoperative state. Simultaneously with the appearance of miosis and anhydrosis the color of the hand improved and a faint radial pulse became palpable. Within thirty minutes all cyanosis had disappeared and the involved hand was warmer than the control hand. A good radial pulse was felt at this time.

The remainder of the patient's course was uneventful. There was no recurrence of circulatory impairment and twenty months after operation the patient has an excellent anatomic and functional result (Fig 142).



the position of the fragments, but failed to improve the circulation. Over the next twelve hours all variations from full extension to hyperflexion of the elbow were tried in an attempt to find the optimum position to relieve the circulatory impairment. Eighteen hours after admission there had been no improvement and exploration was performed.

*Operation*—The brachial artery was found to be in contact with the anterior edge of the proximal fragment of the humerus, but there was



Fig 141—X-rays of elbow on admission

no evidence of compression. Instead, the entire exposed segment of the vessel proximal to the point of contact was in a state of marked spasm, the diameter being estimated as 3 mm. Distal to the point of contact the vessel measured 5 to 6 mm in diameter. The artery was free of any other organic occlusion proximal or distal to the point of contact. Over a period of time it was found that at intervals a faint pulse could be detected, but this disappeared after fifteen to thirty seconds. These periods of

avoided. This is well illustrated by a case which we have seen recently\*.

A 21 year-old male was admitted to another hospital with a simple comminuted fracture of the tibia. After closed reduction and application of a cast the patient complained of severe pain and the toes were noted to be cyanotic and cold. The cast was removed and open reduction and plating of the fracture were performed. This failed to improve the circulatory impairment and nine days after the injury the patient was seen in consultation by Dr. Frederick Lee Liebolt. Upon transfer to this Hospital the foot was cold and there were blotchy cyanosis and bleb formation on the lower third of the leg, the dorsum of the foot, the heel and all toes. The dorsalis pedis and posterior tibial pulses could not be felt. Because of the duration of the circulatory impairment, paravertebral sympathectomy was performed by Dr. B. S. Ray after a paravertebral sympathetic block had shown transient improvement in the color, temperature and pain. The patient was carried on intravenous d-benamine until the operation was performed. There was dramatic improvement following sympathectomy. The dorsalis pedis and posterior tibial pulses became palpable, the cyanotic areas on the foot and lower leg improved and lines of demarcation appeared at various levels on the toes. It became obvious that portions of the toes would be lost, but that the circulation was adequate to save the foot. The patient subsequently developed a spreading infection in the region of the bone plate and it is probable that he will lose the leg as a result of the infection.

In this case closed reduction would have been entirely satisfactory and the leg would undoubtedly have been saved if this had been combined with lumbar sympathectomy. Operation served only to increase the demands on an already inadequate circulation and to further impair the circulation by the addition of trauma and edema. The poor healing of any wound in the face of impaired circulation is well known and needs no further comment.

Still the advisability of employing sympathetic paralysis in place of exploration may be questioned since it can be argued that one may overlook an organic occlusion which might be corrected at operation. Nevertheless it is obvious that if sympathetic paralysis improves the blood supply to an extremity sufficiently to maintain normal color and temperature then any organic occlusion which may be present cannot be significant. In the presence of significant organic occlusion paravertebral sympathetic block will either be ineffective or its benefit will be partial and transient. The decision to use repeated blocks, paravertebral sympathectomy or exploration when a single block fails must depend upon the features of the individual case.

The precept regarding the importance of diagnosis and treatment of soft tissue injuries associated with fractures is too often forgotten. In civilian practice segmental arterial spasm will be encountered most frequently in association with fractures. The importance of early diagnosis and treatment cannot be overstressed. While it is beyond the

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\* Dr. F. L. Liebolt, who will report this case in detail at a later date, has kindly permitted inclusion of this brief abstract in this report.

**Comment:** Treatment of the vessel of course at first is based on reported benefit involved extr with this t

procaine, periarterial and paravertebral sympathectomy, and resection of the involved segment have been suggested. Diagnosis is difficult since organic and functional occlusion cannot be differentiated unless the vessel is exposed at operation, or the occlusion can be abolished by adequate sympathetic paralysis. It is suggested, therefore, that paravertebral sympathetic block be employed early, both for its diagnostic and for its therapeutic value. It is probable that paravertebral sympathetic block performed preoperatively in our case would have made the diagnosis clear and operation unnecessary.

While there are differences of opinion regarding the pathologic physiology of segmental arterial spasm, few investigators deny that the sympathetic nervous system plays a significant role. The rhythmic alternation between complete and partial occlusion observed in the case reported is characteristic of sympathetic activity. Rhythmic cycles of varying degrees of sympathetic activity may be observed both in

the role of the vasomotor nerves. Sympathetic paralysis, therefore, constitutes the most rational attack on segmental arterial spasm. This may be achieved by paravertebral block with procaine or by paravertebral sympathectomy.\* Periarterial sympathectomy has little to recommend it. It does not produce adequate sympathetic paralysis and can be justified only by the supposition that it interrupts afferent impulses which initiate and maintain the spasm. Such a mechanism is purely hypothetical. When, however, exposure of the involved artery is necessary, the injection of procaine beneath the adventitia may be tried. If this fails to relieve the spasm, it is doubtful if periarterial stripping

is indicated. Resection of the involved segment is often indicated if organic occlusion is

segmental arterial spasm is faced with impaired circulation to the extremity, he should take advantage of the paravertebral sympathetic block of the vessels, operation which adds more trauma and can make a bad situation worse may be

\* Tetraethylammonium bromide and dibenamine hydrochloride may prove to be of value, but no data regarding their use in segmental arterial spasm are available.

## OBTURATOR NERVE AVULSION IN THE TREATMENT OF PAINFUL HIP JOINTS

EMANUEL B. KAPLAN, M.D., F.A.C.S.\*

### NERVE ENDINGS IN JOINT STRUCTURES

THE reception and transmission of the various sensations connected with joint activity is not well known. What part is played by the capsule of the joint, what part by the synovial membrane, periarticular tendons, muscles and vessels, is yet to be investigated. A review of the special literature concerning the nerves supplying the capsule, the synovia, the hyaline and fibrocartilage shows how little precise information can be obtained.

Sappey, following Bichat, mentioned that experimentation on living animals showed no painful responses when the synovia was touched or irritated. In man, it was equally observed that the synovia is insensible to touch. He further stated that the sensibility of the capsule is very great but quite different from the sensibility of the exterior parts. The ligaments were insensible to touch, compression, division and even cauterization in the living animal in which the capsule of the joint was exposed. But as soon as the joints were submitted to torsion, or elongation, the animal showed signs of pain.

Many investigations were carried out to determine the behavior of various nerve endings in the capsule and synovia. These investigations were made in man and animals and brought conflicting results.

and epiphyses and are vasomotor in function. He states that painful sensations originating in blood vessels are well known, and it is possible that the pain in acute arthritis may have a vascular element. The exact functions of the myelinated axons which supply articular blood vessels are unknown but their terminals may act as receptors of pain and of

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columns involving the posterior and anterior roots, and a simul

scope of this report to discuss the relationship between segmental arterial spasm and Volkmann's ischemic paralysis, the possibility of that relationship is obvious

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pain in the joint is found. However, there is no adequate explanation of the reason for pain in terms of what part of the joint is responsible for it, what pathways are transmitting it, what particular peripheral nerves are involved, or what role is played by the vessels or afferent sympathetic fibers.

Not infrequently one may observe painful hips months after introduction of Smith Petersen nails for treatment of slipping femoral heads in young individuals or for fracture of the neck in older individuals. X ray in these cases may show penetration of the nail into the articular cavity. There are other cases with penetration of the nail into the acetabular cavity without any pain. In cases of severe osteoarthritis pain is explained by the presence of severe changes in the contiguous joint surfaces. However, a simple osteostomy of the McMurray type or modified bifurcation operations are known to produce prolonged relief. In these cases the articular changes may not show any improvement on x ray examination. In certain cases of painful hips, improvement has been obtained by an ingenious fenestration operation of the neck of the femur with implantation of muscle from the surrounding area. In certain cases of vitalium cup arthroplasties, the pain recurs and may change its location only after operation. There are even instances of complete hip fusion which are accompanied by pain in the hip joint. Synovial distentions may or may not be accompanied by pain. Not infrequently the pathological process in the hip joint produces pain localization on the inner, or anterior, or posterior aspect of the knee joint. An osteoid osteoma in the region of the lesser trochanter or in the femoral neck may produce pain in the knee and may be overlooked for a long time. Pain transmitted to the knee and produced by a process in or around the vicinity of the hip joint is usually explained by referred pain over the path of the obturator nerve. No positive proof of this is offered, it being assumed on the basis of textbook descriptions of the course of the obturator nerve.

Although the transmission of pain through the obturator nerve is possible, another possibility should not be overlooked and may be more probable. The compression of the femoral nerve which is much nearer to the head and neck of the femur can transmit pain through the saphenous nerve to the inner aspect of the knee joint. The nerve to the vastus medialis is not infrequently anastomosed with the branches of the obturator nerve and may also be a transmitter of pain from the hip joint to the knee, or the cutaneous branches may be responsible for transmission of pain, if such a pathway through any of these nerves be proved. This can also explain pain in hips treated by insertion of vitalium orthoplastic cups. The vitalium cup is separated from the femoral nerve by a thin layer of ligamentous and muscular tissue and produces mechanical irritation of the nerve with transmission of pain into the anterior and medial aspect of the lower thigh.

aneous unilateral sympathectomy painful sensations enter the cord from the lower extremities by way of the sympathetic ganglia.

The conclusions to which one arrives pertaining to nerve endings in the joint structures and to the pathways which carry painful stimuli to the central nervous system are quite indefinite.

#### NERVE SUPPLY OF THE HIP JOINT AND THE CAUSES OF PAINFUL HIP

Turning to the gross anatomical description of the nerve supply to the hip joint or any joint one finds a steady repetition in the text books of old original descriptions. It is curious to note that some of the original descriptions were based on a limited number of dissections. In the section on the nerve supply to the hip joint in the extensive anatomies of Testut and Charpy and Polrier the usual supply is described. In addition two investigators are mentioned in each of these anatomical treatises who were probably considered important. Mandelstam, one of the investigators never found an articular branch deriving from the obturator nerve supplying the anterior capsule of

and from the nerve to the quadratus femoris muscle for the posterior part

of necessary obturator branches which derive from the posterior division of the obturator nerve either high in the obturator foramen or in the substance of the obturator externus muscle. Sometimes the fine articular branches derive from the anterior division of the obturator nerve

endings is uncertain the physiology of pain is not clear, the part played by the nervous system in the production of arthropathies is not entirely explained. It is unknown which area of the capsule is supplied by each participating nerve how they overlap and what normal variations of

Clinical observation  
are observed very  
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ruffles of the articular surfaces, one believes that in (Fig. 1)

pain in the joint is found. However, there is no adequate explanation of the reason for pain in terms of what part of the joint is responsible for it, what pathways are transmitting it, what particular peripheral nerves are involved, or what role is played by the vessels or afferent sympathetic fibers.

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The difficulties connected with the problem of interpretation of causes of pain are responsible for the many surgical procedures devised for treatment. The important methods include the following: arthrodesing operations, various osteotomies, arthroplasties and acetabuloplasties. They all have their indications.

In recent years a new method was introduced which promises relief of pain without undue risk, which is an important consideration in some of the older and more debilitated patients. It must be emphasized, however, that it did not solve the problem of how pain is transmitted to the central nervous system. It was first introduced in 1933 by Camitz of Sweden, and then in 1934 in France by Tavernier, who reported a series of fifty-seven cases treated between 1934 and 1943. The results obtained in the early attempts were published by LeCat in 1939 and later by P. Vanney in 1941 and by Tavernier in 1942, 1944 and 1945. Luzuy, also of France, reported in 1945 fourteen cases treated by Podovani since 1935.

The treatment, according to Tavernier, consisted in the avulsion of articular branches of the obturator nerve through an incision over the medial side of the femoral triangle. The simplicity of the method and the reported satisfactory results appeared very promising.

It was then decided to investigate the relation of the obturator nerve to the capsule of the hip joint and to apply this method of operation in suitable cases.

The anatomical study was made on four hip joints dissected by the author and on twenty-four cadavers dissected by the more skillful first-year medical students at the College of Physicians and Surgeons at Columbia University. A thorough dissection of the articular branches is a very tedious and exacting task. The use of magnification is frequently required. The description given by Truchet was con-

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femoral epiphysis, and at the same time  
was necessary for proper anatomical exposure. Before resection of the pubic horizontal branch, the pubofemoral part of the capsule was separated from its medial attachment for better visualization of the articular branches which supply this ligament. The articular branch  
...terior  
...nerve  
...brevis  
penetrated between the adductor  
muscles and the deep branch entered the space between the adductor  
brevis and the adductor magnus. The articular branch to the anterior  
capsule has been seen originating either from the anterior or from  
the posterior branch of the obturator nerve. The other articular

branch frequently described as entering the head of the femur through the round ligament could not be followed. The articular branch is usually of small size. At times it divided into several very thin filaments. When the articular branches are buried in the substance of the obturator externus it is difficult to trace it with precision.

The dissection of the articular branches deriving from the femoral nerve and supplying the part of the anterior capsule and the ilio femoral ligament was found to be quite arduous. These branches could not be surely identified in a notable number of dissected hips.

The investigation of the nerve supply to the hip joint would be more complete if the articular branches of the femoral and obturator nerves were followed to their microscopic termination in the ligaments of the capsule. This however would involve a complete research problem outside of the immediate scope of this investigation. In spite of the limitations of the study it permitted the conclusion that the nerve supply to the anterior capsule derives largely from the obturator nerve whose articular branches are more accessible to surgical procedures. This is in partial agreement with the statement of Tavernier. He found that the deep posterior branch of the obturator nerve supplied the greatest part of the anterior capsule of the hip joint.

#### OBTURATOR NERVE AVULSION AS A FORM OF TREATMENT

In the first attempts Tavernier practiced a resection of the deep branch of the obturator nerve but with the development of his technique confined his resections to the visible articular branches abandoning the complete avulsion of the deep branch of the obturator nerve as perhaps too mutilating.

Our first operation was performed on October 20, 1945. The patient was suffering with an advanced form of Marie-Strumpell arthritis involving the spine and both hip joints. Prior to the operation the patient was bedridden for about five months. To insure the removal of all the articular branches and to relieve the adduction contracture of the hip joint a complete avulsion of the obturator nerve at the exit from the obturator foramen was done. The nerve was approached

as relieved sufficiently to return to his occupation of gardening.

**Novocain Test**—Before the operation a *test* injection of novocain in the area of the obturator nerve is done. The patient is placed flat on the back and the affected extremity abducted to bring out the adductor longus. A needle 2 inches long gauge 22 is then introduced near the insertion of the adductor longus close to its lateral border and pushed down to the horizontal ramus of the pubis. As soon as the bone is reached the point of the needle is deflected down under the

The difficulties connected with the problem of interpretation of causes of pain are responsible for the many surgical procedures devised for treatment. The important methods include the following arthrodesing operations, various osteotomies, arthroplasties and acetabuloplasties. They all have their indications.

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The anatomical study was made on four hip joints dissected by the author and on twenty four cadavers dissected by the more skillful first year medical students at the College of Physicians and Surgeons at Columbia University. A thorough dissection of the articular

branch of the obturator nerve was made. The articular branch of the obturator nerve was found to be a small branch which arises from the main trunk of the nerve and passes between the adductor longus and the adductor brevis muscles. It was found that the articular branch of the obturator nerve was necessary for proper anatomical exposure. Before resection of the articular branch of the obturator nerve, the articular branch of the obturator nerve was found to be a small branch which arises from the main trunk of the nerve and passes between the adductor longus and the adductor brevis muscles.

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and posterior branch. The anterior branch of the obturator nerve penetrated between the adductor longus and the adductor brevis muscles and the deep branch entered the space between the adductor brevis and the adductor magnus. The articular branch to the anterior capsule has been seen originating either from the anterior or from the posterior branch of the obturator nerve. The other articular

**Results.**—Following the first successful result fifty three additional patients were submitted to the operation by the author and other surgeons at the Hospital for Joint Diseases. The cases were selected mostly for relief of pain due to arthritis or extensive operative procedures and the results were considered good when the pain diminished sufficiently to permit the patient to walk, and satisfactory when the patient had marked relief at rest.

The following observations were made in the majority of successful cases

- 1 As soon as the patient recovers from anesthesia the absence of pain is noticed
- 2 The patient is able to get out of bed within one or two days following the operation
- 3 No sensory disturbances are noticed on the inner aspect of the thigh or knee
- 4 Adduction is possible and is rarely weakened
- 5 The patient is able to walk with more ease, if prior to operation there was no severe deformity. In certain cases the pain disappeared after operation but recurred after a varying period of time

Röntgenographic examination of the joints after resection of this nerve did not show any changes suggestive of trophic disturbances in the acetabulum or head of the femur immediately after the operation or at later dates.

In the fifty four cases in which operation was done, four patients had a bilateral avulsion of the obturator nerve. The remaining fifty had an avulsion in one extremity only. Ten patients had an excellent early and late result. Seven patients had a good result. Nineteen patients improved. Seven patients had no improvement. In eleven cases the information was not complete. The following table summarizes the results.

The longest period of observation after operation was only of about two years' duration. It is impossible to foresee whether these cases will remain painless with the patients capable of carrying on their activities.

Subsequent to the first reports on the results of obturator nerve resection, Tavernier introduced an additional method of hip joint denervation. Through an incision in the gluteal region, he interrupted the nerve to the quadratus femoris muscle in cases of persistent pain in the posterior region of the hip joint. This method has not been used as yet in our series of cases.

The technical simplicity of the obturator nerve avulsion and a fair number of satisfactory results permits the assumption that this procedure may be of help in many instances.

horizontal ramus and pushed about 1 to 1.5 cm into the foramen. Ten cubic centimeters of 1 per cent novocain without adrenalin is injected.

Relief of pain after the injection is considered an indication for operative resection of the obturator nerve.

**Technic.**—The surgical procedure is simple and the best approach is over the femoral triangle. A 2 to 3 inch incision is made parallel to the lateral border of the adductor longus muscle, which can be palpated on abduction of the hip, or easily found by connecting the pubic tubercle with the point of intersection of the sartorius with a line representing the anterior axis of the thigh. In the male patient, care must be taken to avoid accidental division of the spermatic cord near the pubic tubercle. After the skin incision, several layers of fat separated by fascial layers are encountered, especially in obese subjects. The fascial planes should not be mistaken for the deep fascia covering the muscles of the femoral triangle. As soon as the deep fascia is bared, the long saphenous vein is recognized and retracted.

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adductor longus muscle. The space between the adductor longus and the pectineus muscle is easily found and separated bluntly. It may be observed at times that the pectineus muscle is overdeveloped and hinders the exposure of the obturator nerve. It can be easily divided near its origin from the pectineal line. The separation of these two muscles uncovers a space filled with fat and crossed by vessels deriving from the obturator and the medial circumflex arteries and veins. Ligation of these vessels is a simple and rapid step. By gentle separation of the fat the anterior branch of the obturator nerve is found and followed to the point of exit from the obturator foramen. The identification of the articular branches is apparently difficult, if at all possible. It is best then to divide the nerve at the point of exit and avulse it as high as possible. The avulsion involves the two branches. No special closure is necessary. A few sutures in the subcutaneous tissue and skin is all that is required.

It is possible, of course, to approach the obturator nerve through the suprapubic route, as described by Chandler, or through a medial incision between the adductor longus and the gracilis muscles.

However, many patients with painful hips are in the middle age group and are obese. The approach to the obturator nerve in these patients is somewhat more difficult through the suprapubic region. If an adductor tenotomy is required, an additional incision becomes necessary.

The medial incision, as advised by Stoffel, does not give a direct exposure of the obturator nerve. The approach through the femoral triangle is therefore, considered the most direct and simple.

# THE TREATMENT OF PAINFUL PHANTOM LIMB

## A Follow-up Study

C G. DE GUITERREZ-MAHONEY, M D, F A C S \*

PAINFUL phantom limb has long been a very trying problem to treat, and because of the need for a method of managing the more difficult cases the suggestion was made in 1944<sup>1</sup> that resection of the postcentral cortex corresponding to the amputated limb would alleviate the condition. The present report is intended to review the patients treated by the author with this method. There have been several notices of the application of the method, some of which have been favorable and others unsuccessful, and it is hoped that in the future a composite report of all these cases might be made which will give a more adequate impression than the few cases now submitted.

### ILLUSTRATIVE CASE HISTORIES

The first patient was a 40 year old man who had lost parts of the middle and ring fingers of the right hand and subsequently suffered distracting pain in the phantom fingers. The left postcentral cortex for these fingers was removed with the result that he was relieved of his pain so that he was able to work. When last seen two years after his operation he was leaving to enter the Merchant Marine. Nothing has been heard of him since then.

The second patient was a 24 year old man who had injured and destroyed his left brachial plexus in a crushing truck accident. No repair was possible. He suffered a painful phantom limb, and a section of his right postcentral cortex corresponding to the limb was removed. This relieved him of pain which had necessitated using morphine at frequent intervals. He was last seen six months after the cortical operation. He had -----  
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due to the brachial plexus destruction. The arm was subsequently amputated after his discharge from military service. He must have continued to complain, for a chorodotomy at the third cervical level was later done at a Veterans' Hospital. A neurosurgeon's report three years after the cortical resection indicated that this man was "not having sufficient pain to justify any further major surgery." This had

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unjustifiable resulting disabilities. In some instances, removal of the precentral and postcentral cortex concerned with an amputated limb might give adequate partial relief to recommend the procedure but for the more difficult patients, frontal leucotomy will probably have to be the operation of choice.

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also been my opinion when he was last seen sometime before the amputation and chordotomy. So, it would seem that considerable relief had been obtained by this man from the resection of the postcentral cortex.

The third patient was a 56 year old man who had sustained an amputation at midthigh, following which he had a painful phantom limb. For this three operations (chordotomies) had been performed the last a year before he was first seen by me. A variation in the cerebral operation was made in this instance the left precentral as well as the postcentral cortex corresponding to the right lower extrem-

pain, principally in the hip. This has varied and has been less bothersome when traveling than when resting at home.

become a severe morphine addict. The right postcentral cortex corresponding to the left leg was removed, a year later he still had pain in the stump and some phantom sensations but he had relief of his painful phantom phenomena after operation.

### SUMMARY

These four cases indicate that removal of the postcentral cortex corresponding to a painful phantom is only partially effective in controlling the discomfort associated with the phenomenon. The procedure was developed with the intent of eliminating the point of registration of impulses beginning in the amputation stump. The hypothesis that such sensations registered only in the postcentral cortex and in specific areas for specific parts has thus been shown to be false. More attention should probably have been paid to the early studies of Dusser de Barenne<sup>2</sup> who showed in monkeys that the cortical sensory representation extended for a considerable distance anterior and posterior to the central fissure. More recent observations by Woolsey<sup>3</sup> and others also have shown that cortical sensory representation is more extensive than previously localized in the postcentral cortex, through the discovery of the so called second sensory cortex.

Thus it would seem that the possibility of eliminating all sensation from a part by removal of cerebral cortex is not feasible since the cortical sensory representation is too extensive. The excision of adequate cortex to desensitize a part would be associated with other

of these traumatic lesions with opiates would have been fraught with the danger of unavoidable depression from these drugs with no possible benefit to the patients

Fortunately, the understanding and therefore the management of pain has recently captured the imagination of many research laboratories and a large number of clinicians in the several special practices of medicine. The coordinated scientific studies of the characteristics of pain, its effect on biological activity and the reaction of patients to the pain experience have provided the basis for significant advances in its conquest and a more optimistic outlook for its control

### CLASSIFICATION OF PAINFUL STATES

Recent efforts in the study and understanding of pain mechanisms have pointed a more scientific approach to therapy. A descriptive classification of painful states, based upon etiology and quality of experience, has been useful in beginning an organized attack upon the pain of disease. As to *etiology*, the largest group of painful syndromes is associated with the organic change in the tissues of the visceral and musculoskeletal system resulting from infection, trauma and neoplasm. The next group is the painful states of neurological origin, e.g., the neuralgias and neuritides. The third group is that consequent to spasm of smooth muscle of the digestive, urinary or circulatory systems. The last group consists of patients who experience pain in the absence of demonstrable etiological factors—the “psychogenic” type of pain. Obviously this classification of painful states is of limited utility, but it is of assistance in promoting a clarified approach to therapy.

Another, and perhaps more useful classification of pain, is concerned with the *quality of the pain sensation*. Pain which is burning, itching, sharp or stabbing in nature is superficial in origin and is associated with a positive reaction pattern on the part of the patient in that he wishes to do something definite about the pain. This is the response of the patient who has a toothache. It is also seen in such injuries as skin lacerations and thermal burns which are not severe. The patient doesn't “take” it. He is anxious to take positive steps in rectification either by removal of the offending part or his removal from the threatening environment. He is frequently incensed and angry with his pain.

The other type of pain, originating in viscera deep in the soma, is aching, gnawing and throbbing in character. It causes the patient to withdraw or rest. The abdominal pain in intestinal lesions of inflammatory origin typifies this response. The victim wants to be left alone with his pain.

## ADDITIONAL ARTICLES

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### THERAPY OF PAIN

E A ROVENSTINE M D \* AND E M PALPER M D †

PAIN is the cry of nature in distress. It is a cry that has echoed throughout the ages of medicine. Its eradication has been a foremost goal of all who practice the healing art. It has engaged for all time the energies of civilized man and yet its adequate control cannot be reviewed as a brilliant chapter in the history of medicine.

The therapy of pain is not limited to any specialty in medical practice. It is the day by day business of every doctor. But there is an intimate association of such therapy with anesthesia. In the laymen's library this association is brought close with such recent titles as Victor Robinson's "Victory over Pain" and Rapers "Man against Pain" and others. Such publications direct attention to the anesthetists' exclusive role in controlling pain induced by surgical manipulations. This role has always been accepted as the primary obligation of anesthetists but events in the changing medical world have made it imperative that our functions be broadened and that we accept the challenge of pain occurring outside the surgical amphitheater. Such a concept fully justifies this anesthesia clinic on the therapy of pain.

Too often in the past physicians have aligned themselves at the extremes of mistaken humanitarianism in prescribing narcotics in excessive dosage or in considering pain as merely a symptom which furnishes a clue to the diagnosis of a specific lesion to the neglect of the sufferer's comfort. It is now evident that various painful states deserve intelligent appraisal and perhaps equally vital a systematic plan for relief which will conserve the patient's social usefulness.

allowed to persist. For example Beecher<sup>1</sup> in studying 215 badly wounded soldiers found that only 24 per cent had pain which they considered severe. Pain being an unimportant factor the treatment

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### THE PAIN THRESHOLD

*Any classification of the pain syndrome is inadequate without consideration of the pain threshold. Although some investigators consider the threshold to pain a fairly constant physiological phenomenon there is extensive clinical support for the thesis that there is a considerable variation in pain threshold in different individuals and in the same individual at different times. This variation in pain threshold seems to be associated with personality traits and alterations in emotional texture. Some people can tolerate considerably more pain than others but even the more stolid among us have their moments of increased susceptibility to pain. The concept of pain threshold is a definite one and certainly not a new development. It is only recently however that promising scientific efforts have been made to measure pain threshold quantitatively in man. Wolff and his associates<sup>2</sup> have employed the response to heat and have been able to study in relative terms the influence of drugs and other factors upon pain threshold. Similar studies were completed by Seevers employing the von Frey principle in evaluating the analgesic properties of anesthetic gases in small concentrations.*

Another method of observing the threshold to pain has been described by Hollander. The device employed is a jagged strip of metal which is placed on the skin surface of the arm and surrounded by a sphygmomanometer cuff. Pain threshold may be measured by the pressure in the cuff required to produce pain. In rough terms the threshold is high if 200 mm. of mercury can be tolerated before pain is experienced and low if 120 mm. of mercury pressure will elicit discomfort.

Pain threshold may be modified by several factors in the environment or intrinsic in the subject. Physical alteration of the skin receptors may for example

processes in the history of the patient who has suffered a long time and is no longer able to endure the same painful stimuli with equanimity. Perhaps most significant of all is the influence of attitude—the psychological factor. Distraction and simple fatigue can increase the pain threshold up to 35 per cent. More intensive emotional experiences are capable of completely distorting ordinary concepts of pain perception. The

Finally the pain threshold is much to be expected as a

is the consistently important application in clinical medicine. The use of drugs, although not always properly executed, is the only realistic method of elevating pain threshold in the therapy of disease.

### THE THERAPEUTIC ATTACK ON PAIN

The therapeutic attack on pain is directed along one or more of several directions, based upon some of the considerations discussed above.

**Abolition of the Pain Stimulus.**—The first and obvious approach to therapy is the abolition of the pain stimulus if at all feasible. It seems unnecessary to elaborate further on this point since the elimination of the source of pain is almost axiomatic behavior on the part of most physicians. However, it needs mention because there is a tendency in a busy practice for a physician to resort to analgesic drugs or even more radical measures without thinking of the simple things first.

**Interruption of Pain Pathways.**—The second attack upon the pain syndrome is directed toward the elimination or interruption of pain pathways chemically or surgically. This is not the place to recount in great detail the tremendous strides in the management of pain which have taken place in neurosurgical circles except to point out that there still remains a great deal of study in the selection of patients for operation and in the acquisition of knowledge to improve the actual results of surgical intervention.

Nerve pathways may also be interrupted by *nerve block* procedures. The nerve block clinic is a University Department in addition to medical

practice. Prior to the recent war, relatively few individuals or groups were conducting organized efforts to treat painful states with the methods of regional anesthesia. During the war, large numbers of physicians became attracted to the performance of nerve block. The deceptive simplicity of injecting solutions with a needle and syringe developed a reputation of failure for these methods. The failures and accidents were not those intrinsic in nerve blocking but were due to the failure of operators to master technique, to learn something of the underlying pain mechanisms, and to realize the limitations inherent in

nerve blocking. If nerve blocking is to become a useful clinical tool in the conquest of pain, a completely new orientation is needed. The object of study is not the technique of blocking but the underlying mechanism of pain. It is not enough to know that a certain drug will block pain; it is necessary to know why it does so.

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Pain threshold may be modified by several factors in the environment or intrinsic in the subject. Physical alteration of the skin receptors may affect threshold to pain. In sunburn of superficial nature for example, the pain threshold is definitely decreased. Pathological processes in a patient may alter pain threshold. This is the typical story of the patient who has suffered a long time and is no longer able to endure the same painful stimuli with equanimity. Perhaps

reported Accidental pneumothorax, high spinal anesthesia, collapse of circulation and respiration have been encountered Even death is not unknown Bilateral stellate block with procaine in a patient with chronic asthma was followed by sudden death a few minutes after injection was completed Further details are unnecessary for the present purpose to emphasize that therapeutic nerve blocking is not a simple plunge of a syringe piston and that expert judgment and technical skill are required of the physician who includes this method in his attack upon pain

Nerve block has a definite and valuable application in the therapeutic approach to the patient with pain Its use in vasospasm, myalgia, causalgias, phantom pain sprains and other recognizable conditions is well established Its role in the intractable pain of malignancy and in certain chronic diseases of the musculoskeletal system require much more study and experience for proper evaluation The further study also implies the development of more efficient agents to produce prolonged blockade without toxic side effects

**Raising of the Pain Threshold.**—A third approach to the therapy of pain is a common one in clinical practice It has as its aim the raising of the pain threshold which is regularly accomplished with drugs which depress brain centers concerned with the reception of impulses carrying pain Possibly no greater misuse of drugs has been seen in medicine than the misapplication of analgesic drugs Special reference is made to the opiates which have significant effects other than analgesia and these are completely ignored to the detriment of the patient It has been shown that the pain threshold of a young healthy adult cannot be raised beyond a certain amount and that 30 mg of morphine accounts for the maximum It is true, of course, that the maximum is administered infrequently, but it is surprising how often morphine is prescribed in doses larger than required for analgesia Despite the large experience all physicians in most specialties have with morphine, it has been far from satisfactory to patient and physician because of its addiction faculties and the side effects listed below The dissatisfaction with morphine and the other potent opiates rarely admitted, is proved by the enthusiastic reception which opiate substitutes receive as they are offered to the profession Demerol one of the popular substitutes, while very useful, has not been completely free of the untoward addiction or depressant properties of morphine and has not removed morphine from the list of frequently used drugs Recently amidon hydrochloride (methadon) has been studied as a morphine substitute and appears to be promising in that side reactions and tolerance are said to be minimal However, caution is required in holding the perennial successor to morphine—disappointments have been too common

The disadvantages consequent to the administration of morphine in



the unbroken skin impose enough inaccuracy without accepting the additional one of carelessness in execution. Nerve block must be performed carefully and correctly with meticulous attention to anatomy.

tempted. There are other completely unknown factors which also mitigate against spectacular results, but clinical experience will furnish clues to the sorting out of these cases. It is difficult to determine, for example, why herpes zoster will respond so well to procaine block if the intercostal nerves are involved, and so poorly if the brachial or lumbosacral plexuses are affected. These observations about nerve block are of great importance in prognosis and in utilizing

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used effectively in the neuralgias, the pain of herpes zoster, and other

block of the regional sympathetic ganglia have shown a valuable place in providing symptomatic relief to allow time for more adequate preparation of a patient for definitive surgery. Alcoholization of branches of the trigeminal nerve for the pain of the douloureux is frequently performed for the relief of pain in patients unsuited for surgery or unwilling to undertake the more major therapeutic offering. Finally, nerve block has great value as a diagnostic implement for internist and surgeon. The method lends itself to the proper selection of patients for surgical interruption of nerve pathways, for the diagnosis of abnormalities of vasomotor tone and as assistance in the separation of patients whose pain is psychogenic from those whose suffering is organic in nature.

they still occur. The use of alcohol is not uncommon and may lead to pain which is more intractable than the pain of the original lesion. Paralysis has been

doses are administered Scopolamine is a valuable adjunct to opiate medication in that it serves well to reduce the psychic trauma of pain and other unpleasant situations. It definitely alters the reaction pattern almost to the point of unreality in the sense that the patient experiences a greater sense of euphoria than the situation warrants. It has been observed also that small doses of the barbiturates are effective in controlling traumatic pain in instances where morphine had not been completely satisfactory. Since the barbiturates have no analgesic properties it seems likely that their beneficial effect upon pain must be associated with some modification of the central perception of pain.

**Deadening the Perception of Pain**—Of course complete pain relief is effected also by rendering the patient unable to perceive pain. This is the original interest and activity of the anesthesiologist and its largest application in medicine is accomplished during surgical anesthesia. It may be produced with large amounts of depressant drugs of the many groups employed in the clinic. It seems unnecessary to point out that this form of pain relief has no place in the therapy of chronic pain syndromes.

**Physical Measures**—This discussion would not be complete without mention of some of the physical measures directed toward the control of pain. These measures include heat, cold, massage, hydrotherapy, manipulations and radiation, all of which are most important in providing comfort of patients in pain.

**Specific Remedies**—In addition there are some specific remedies directed toward specific types of pain. Drugs such as curare reduce painful muscle spasms in poliomyelitis and ergotamine may overcome the dilating pulsations of cranial vessels in migraine. Colchicine is useful in gout and the salicylates in rheumatic fever and many different types of pain. Nitroglycerin is of great value in the pain of angina. Cobra venom has a definite place in the therapy of a variety of painful syndromes. Other specific remedies will occur to the alert physician.

**Remarks**—A final word is necessary concerning the administration of depressant drugs to the point of stupefaction. The barbiturates and the opiates have been employed in excessive dosage on occasion with the production of markedly depressed states. Properly considered the usage of these drugs in this manner must be unphysiological. Stupefaction cannot be acceptable pain therapy.

#### SUMMARY

A brief review of some of the aspects of pain has been presented  
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suggest the complications which may be encountered. Respiratory depression and the production of sleep are frequently associated with morphine and are certainly unnecessary components of effective analgesia. It is evident that morphine is far from being a safe drug efficient in the raising of the pain threshold despite its ubiquitous usage in practice.

More recently in an effort to secure analgesia in the postoperative period uncomplicated by the respiratory depression and other untoward effects of the opiates there has been an increasing tendency to employ dilute solutions of procaine intravenously. The efficiency of this type of therapy in securing analgesia must be admitted readily. Its final role and proper selection for the types of pain which respond remain for further study and experience. Intravenous procaine certainly must be considered for the patient with pain in whom excessive dosage of opiates is otherwise required.

**Modification of the Reaction Pattern**—Another and very important technic in the management of the painful states is the modification of the reaction pattern exhibited by the patient to a painful stimulus. This is an important consideration for the patient because the response to pain or the pattern of behavior may be as disabling or more so than the perception of pain per se. Attempts to minimize or abolish the emotional overtones associated with pain are definitely useful therapeutic measures. The response to pain may be stereotyped and subject to influences other than drugs alone. There are many psychological aids which can be of enormous comfort to the patient.

The efficiency of the placebo is real if one considers that fully one third of patients studied with regard to the potency of new analgesic drugs will exhibit pain relief as satisfactory following a placebo as the active drug itself provides.

The reaction pattern may be modified by drugs and the opiates have probably enjoyed the greatest success in this sphere. It is difficult to evaluate these effects quantitatively but it has been demonstrated that the *sense of well being precedes the analgesic effect* of morphine and outlasts it. Essentially the principle is one of allaying anxiety and apprehension. Alcohol has a similar effect when large

## PREOPERATIVE AND POSTOPERATIVE TREATMENT IN HEPATO-BILIARY DISEASE\*

BOC PRIBRAM MD PhD FICS\*

When elaborating a plan for conservative treatment it is always wise to consider from the very beginning that the necessity of surgical intervention may arise at any time and that all preoperative measures should be completed for such an event

There was a time when "active conservative treatment" for gallstone disease was in vogue. That is to say injections were given with the aim of encouraging bile flow and provoking contraction of the gall bladder with the hope of expelling stones (pitressin acetylcholine et cetera). This procedure has since been condemned and has actually been abandoned by most physicians. The stones should one really succeed in getting them to move may easily stick in their travel in a much less favorable place than before. Many such incidents have been reported.

### PREOPERATIVE TREATMENT

The following aims should and can be achieved by conservative medical treatment:

**Relief of Pain and Shock in an Acute Attack**—This is most effectively and dramatically obtained by intravenous injection of a mixture of

Atropine sulfate	0.00075 to 0.001 gm
Morphine	0.015 gm
Ephedrine	0.01 gm

The cramps cease the patient becomes comfortable and usually falls asleep. These hemorrhages (et cetera) can be excluded or the patient is ready for surgery.

**Improvement of Local Conditions**—A few remarks about the origin of pain and colic in gallstone disease might not be out of place as opinions are still divided. The following statement is backed by many experiments:

(a) A stone lying in the fundus of the gallbladder does not cause any pain and does not make its presence felt at all.

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The concept of pain threshold and its importance in the clinic is stressed.

An approach to the therapy of pain is included and consists of efforts to remove the pain stimulus interrupt pain pathways elevate the pain threshold alter the reaction pattern to pain render the patient unable to perceive pain and utilize a variety of specific remedies. Details of this regimen are elaborated upon and the specific role of each carefully assessed.

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It is true that the acute symptoms subside the temperature drops and the number of leukocytes decreases giving the impression that the acute inflammatory process has been brought under control However the fallacy of this conclusion has been proved and strongly emphasized by J H Garlock Patients after a high dose treatment with penicillin were operated on In none could a standstill of the inflammatory process be noted Actually some patients even developed complete gangrene of the gallbladder and pericholecystitic abscesses This being so we strongly warn that *penicillin treatment*, by concealing symptoms *invokes a particular danger when applied in acute abdominal infections like acute appendicitis or acute cholecystitis*

**Rehabilitation of the Balance of Fluids, Liver Glycogen, Proteins and Electrolytes**—Measures with this aim are essential preoperative measures never to be neglected

Transfusion of blood or plasma is recommended to restore quickly any minus balance of proteins In jaundiced cases however whole blood transfusions should be restricted and are better replaced by plasma Intravenous glucose saline drip infusions are to be given in order to restore liquid and electrolytic balance Moreover an ample supply of glucose serves to restore liquid and electrolyte balance Further an ample supply of glucose serves to restore the glycogen in the liver

Since postoperative peritonitis has completely disappeared with the introduction of the electrosurgical method (Pribram 1929) hepatic insufficiency remains as the most serious postoperative complication There is enough evidence brought forward both in experimental and clinical medicine that proteolysates and especially the amino acids methionine cystine choline and so forth have a protective effect Ample use of these products should be made both in the preoperative and postoperative treatment

**Combating Acute Liver Edema**—In practically all gallbladder attacks an acute edema of the liver develops It is often still present

(b) The acute gallstone attack is caused by a stone that shifts into the collum cysticus area or slips into the opening of the cystic duct whereupon a violent spasm sets in around the stone

(c) A stone might pass through the papilla without causing any pain. Consequently we are fairly safe in saying that the acute gallstone attack indicates that a stone is passing through the cystic duct into the common duct

(d) A stone impacted in the cystic duct causes an acute occlusion of the gallbladder an incident which is in most cases identical with what is commonly called acute cholecystitis but should rather be called an acute gallbladder because the clinical symptoms of an aseptic hemorrhagic infarction of the gallbladder are identical with those of an acute cholecystitis

Therapeutic measures are to be directed (a) against the spasm and (b) against the sequelae of the obstruction that is to say against a flare up of an inflammation in the gallbladder. The chemical antispasmodics are (a) the belladonna group (atropine etc.) (b) papaverine and (c) amyl nitrate. Barbiturates may be given additionally except in the presence of serious liver damage

**Countermeasures against Local Infection**—Two different and rather opposite measures are recommended: the application of heat (hot water bottle or electric pad) or the application of cold (ice bag). However, this is not a question to leave either to the doctor's or to the nurse's discretion but a principal one requiring discussion

Heat in any form accelerates all biologic processes; cold considerably slows them. In our case this concerns an inflammatory process already in development. We must decide the desired effect

In acute gallbladder i.e. with an obstruction of the cystic duct effusion into the gallbladder and infiltration of the wall, an increase of this process is certainly not desirable since it involves an increase of the inside pressure, a breakdown in some parts of the wall or even the danger of a rupture. The more slowly this inflammatory process develops, the more time is given the body to mobilize its means of self defense. Cold favors localization in all acute inflammations. When on the other hand an inflammatory process is already well localized, acceleration of absorption must be the purpose of therapeutic measures

It is further important to bear in mind that in every acute inflammatory process in the abdominal cavity a certain amount of immunity and self defense gradually develops. The effect of the self defense is the localization of the process. Within this area of localization the development of a certain immunity is of great value to the healing process. Consequently all means favoring localization should be applied. A slowing of the inflammatory process is the best way to give a chance for self defense and immunity to develop. The slowing down

very little to do with the prolongation of the clotting time. The increased permeability and vulnerability of the capillary wall stand in the foreground and the useful effect of calcium in tightening the wall is a well confirmed fact.

The calcium therapy should be carried out as in the old days. The best form of application is in a mixed daily intravenous injection of 10 cc of calcium gluconate plus vitamin C. This prophylactic treatment should start at least three days before operating.

### SURGICAL PROPHYLAXIS IN CASE OF OBSTRUCTIVE JAUNDICE

In spite of all improvement in the biochemical control of postoperative hemorrhage, I wish to stress that surgical measures still rank first. They are

1 *No procrastination or undue delay is warranted in operating for obstructive jaundice.* Formerly, cases of three or four months' duration were quite common, and even now a waiting time of six weeks is considered appropriate by many physicians. This delay is not justified. Ten days are certainly sufficient not only to establish the diagnosis but to complete all necessary preoperative measures. Experience has shown that when the obstruction does not move within ten days, as shown by an unchanged serum bilirubin level, the chance of later spontaneous release of the obstruction is very small.

2 *Blood control when operating should be careful and exact.*

*stones in the ampulla in case of long standing jaundice.* No forcible dilatation of the papilla is indicated. Impacted stones which cannot

measures alone were sufficient to restrict cholemic hemorrhage to a minimum.

Since this surgical prophylaxis forms a most important part in preventing cholemic hemorrhage, a brief discussion of a few important technical points of the main procedures might be useful.

**The Electrocoagulation Method (Mucoclasia)** (Pribram, 1929) — There has been some confusion, misunderstanding and misrepresentation among surgeons who adopted the method. I give, therefore, a short description of the original method which was the result of many



at operations and we may observe how quickly it sometimes disappears while operating. The size of the liver diminishes under our hands. This acute liver edema can be combated successfully and the liver dehydrated by intravenous injection of 20 cc of a 50 per cent glucose solution. No thrombosis occurs when some technical rules are observed as follows: (a) strict avoidance of injury to the posterior wall of the vein; (b) aspiration of 1 to 2 cc of blood before the solution is slowly injected; and (c) elevation of the arm right after the injection and compression of the puncture in order to avoid any reflux of blood and glucose into the paravenous tissue.

**Cell-Cleaning Effect of Hypertonic Glucose Solution**—Hypertonic glucose solution intravenously administered has another interesting effect on the liver cells. It causes the liver cells to discharge like iron pigment. This cell cleaning

**Prophylaxis Against Cholemic Hemorrhage**—Only vitamin K preparations are absorbed from the intestinal tract only with the help of bile salts which have to be given simultaneously when vitamin K is orally administered. The new synthetic naphthoquinone products (menadione, hykinone) can be given parenterally without bile salts and have almost entirely replaced the original vitamin K.

Treatment with vitamin K or the synthetic products should not be blind routine. It should be guided by the actual prothrombin level and its response to a vitamin K injection. If the response is poor, higher doses and longer preoperative treatment is imperative. The treatment has to be continued for at least six or seven days in the postoperative course. Hemorrhagic complications are reported as long as several weeks after the operation.

recent times because experimentally no definite influence on coagulation time has been proved when calcium was applied even in large doses.

However, leaving apart the well established role that the calcium ion plays in the physiologic processes of coagulation, some experiments point to a serious disturbance of calcium metabolism in cholemic patients. This disturbance increases as time goes on. In case of a complicating pancreatitis the calcium level in the serum drops considerably.

An important value of calcium application lies in my opinion in its effect on the capillary walls. We must distinguish strictly between

\* See *American Journal of Digestive Diseases* and the author's book "Hepatobiliary Diseases" to be published by Charles C Thomas.

No death from cholemic hemorrhage has been observed since the electrosurgical method has been applied. Postoperative peritonitis as a cause of mortality has completely disappeared. The mortality in 850 cases of cholecystolithiasis, including gangrene, ruptures and abscesses dropped to 0.9 per cent and in 1369 cases including common duct surgery, to 2.9 per cent.

**Management of Impacted Stones**—Any forcible removal of the stones in case of cholemic danger should be avoided. Forcible dilatation of the papilla, when liberated, is not a good procedure. It may involve immediate danger and may be followed by strictures of the papilla in the later course. The ether method for such cases has proved entirely satisfactory and has contributed a great deal to the lowering of the mortality.

Only recently has there been full recognition of the importance of maintaining the balance of proteins, electrolytes and fluids through blood and plasma transfusions and the importance of a high protein diet and vitamin K. I wish to stress, therefore, that my observations, covering a period of more than twenty years, partly date back to a time when transfusions were given only in exceptional cases, and when vitamin K was not yet a routine treatment for cholemia. Methods like the ether treatment and electrosurgical operation which were able to banish these dangerous complications almost completely, should be valued from this point of view.

### POSTOPERATIVE TREATMENT

This treatment already starts in the operating room. First, attention has to be paid to the signs of a shock: the respiratory state, the blood pressure and the peripheral circulation. Presence of a shock is indicated when the blood pressure is under the patient's individual level. Blood, plasma or glucose saline transfusion has to be continued. A pulse rate higher than normal gives the same indications for further transfusion.

**Respiratory Tract**—It is a useful preventive measure to remove all collections of mucus in the bronchial tract by suction while the patient is still on the operating table. Frequent inhalation of carbon dioxide greatly helps ventilation of the lungs. The patient awakens quickly with this procedure. Careful preoperative preparation and the routine use of spinal anesthesia have considerably cut down the danger of lung complications. The observation may be made that, in case of operations on the liver and the biliary tract, congestion of the right lower lobe of the lung develops rather frequently, whereas in operations on the spleen, the left lower lobe is in a certain danger. This fact suggests that pulling on the diaphragm should be avoided when operating. When using the high costal incision, the perfect exposure always enables us to operate without any pull on the liver. It may be, of course, that this characteristic unilateral lung congestion

preliminary experiences and which has not been changed now for twenty years

*Procedure in Simple (Acute or Chronic) Cholecystolithiasis without Serious Damage to Free Wall of Gallbladder*—The serosa of the free wall in such cases can always be saved for covering the liver bed and cystic stump. These are cases in which a subserous excision would serve all purposes perfectly well in removing the bladder while preserving the outer serosa for peritonization. However, this is done much more quickly and easily with the electrosurgical method. Moreover the coagulation secures safe hemostasis.

(a) The cystic stump is exposed and severed between two silk ligatures. This exposure alone when properly done usually saves

order to seal off all blood vessels and bile ducts.

(c) For preservation of the serosa of the *free* wall, the electrocoagulation there should be *graded* according to the thickness of the wall. When one becomes familiar with the method it is easy to destroy only the mucous and submucous layers preserving the serosa alone. Many experiments and microscopic examinations have proved that this result can be obtained safely. This being so it would be a foolish move to destroy unnecessarily this most valuable and intact serosa.

*serosa of the free wall is still shining and intact a frequent occurrence.* In such cases also the serosa can be at least partially saved by a graded coagulation.

*The wall of the gallbladder is phlegmonous and contains abscesses.* In these cases there is no point in trying to preserve the serosa. The whole wall is cut away with the diathermy knife at the level of the liver bed and the latter thoroughly electrocoagulated. The electro

be left for forty-eight hours

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A man (Chinese 54 years of age) was admitted for operation with an obstructive jaundice which had lasted four months. His general state was poor and he had formed a serious complication

cholangiogram to be free. However the drainage was sustained for another ten days in consideration of the cholangitis. The general state of the patient was fair and his appetite returned.

Neohemoplastin has frequently proved to be of extreme value in my practice and I feel that its usefulness overshadowed by vitamin K preparations should be known. The idea on which this preparation is based is not a new one, as in the case of vitamin K. It has been given the name hemostatic serum. It is a blood derivative containing prothrombin, thrombokinase and antithrombin. Its protein content sometimes caused an unpleasant reaction in the past but the new preparation is now completely free from proteins, peptones and peptides and shows a negative Biuret reaction. The preparation is tested in a way that a single dose of 2 cc. must reduce the blood clotting time to one third. I am satisfied as to the value of this preparation in all cases of hemorrhage.

**Peritonitis**—While peritonitis following an operation of the stomach or intestines must be considered as almost invariably fatal, this is not the case in a peritonitis caused by bile leakage into the peritoneal cavity. However it is essential that such an incident should be recognized at the earliest date. The signs are: The abdomen is distended and the

spreading of the abdominal pain to the right lower quadrant. Bilirubin level in the serum rises and the patient looks slightly jaundiced. Reoperation is imperative.

At reoperation it is advisable to open the abdomen with a fresh incision in the right lower quadrant. We find that the epiperitoneal and the retroperitoneal spaces are edematous and bile stained. Liquid bile may or may not pour out of the opened peritoneal cavity. How



to empty the duct completely by preliminary aspiration of the bile. Next the stones from the hepatic duct are worked down towards the ampulla and the hepatic duct provisionally closed with a soft rubber clamp while removing the stones from the choledochus and the papilla. A simple rubber tube or catheter is introduced down to the ampulla for drainage and the wall of the common duct stitched water-tight around it.

The tube is closed with a stopper and remains so for several hours after the operation. It is opened only in intervals to allow some drainage, which may gradually be increased. In case of still persistent papillary obstruction and if the patient has to undergo ether treatment, the stopper is opened as soon as the patient complains of feeling pressure. Ravdin recommends pressure regulation through a Y-shaped manometer.

In former days the dressing of the patient usually was soaked with bile the days following the operation. This should and can be prevented. The dressing, even in case of common duct drainage, should remain perfectly dry.

*Treatment of Hepatic Insufficiency*—The conditions leading to hepatic coma are certainly very complicated. It is evident that they are not covered with the term "cholema" as the example of decomposition coma clearly shows. The intimate connection between hepatic disease and the central nervous system should be remembered. In some cases of infective hepatitis, nervous and precomatous signs may appear already in the early stages.

Hepatic coma, further, cannot be explained simply by the breakdown of the glycogen stores. In some instances the liver cells still contain sufficient glycogen. Intravenous drip infusion may have dramatic effect in some cases and in others none at all. I have seen better results with injection of 20 to 40 cc of a 50 per cent glucose solution three to four times a day than with permanent drip infusion. Intravenous injections of calcium gluconate should always be given (10 to 20 cc daily) accompanied by large doses of vitamin C and B complex. Parenteral administration of proteolysates and amino acids (methionine, choline, cystine) should be tried.

There are pros and cons on the question of large infusions of whole blood in case of . . . . .  
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 able. Venal se- . . . . . d trans-  
 fusion of 500 cc . . . . . ults can  
 be reported also with intravenous infusion of a combined salt solution (including citrates) with so called "normet" serum. Phosphorus salts are indicated.

**Bowel Movement**—The onset of peristalsis and the normal movement of bowels is a safe sign of abdominal recovery. Therefore, the surgeon's attention has always been concentrated on this favorable

ever a rubber tube pushed upwards into the gallbladder region suffices in most cases to bring about dramatic improvement

**Hepatic Insufficiency and Coma Hepaticum Following Decompression**—Since postoperative peritonitis as a cause of mortality could be eliminated through the progress of operative technic described hepatic insufficiency in the postoperative course ranks first as danger for patients operated on for long standing jaundice

We operate upon a patient with obstructive jaundice that has lasted for weeks or months Jaundice is considerable but the patient appar

and the recovery seems to be uneventful From the fifth to the eighth day a slight drowsiness appears as the first sign of a turn for the worse The drowsiness increases the patient sleeps almost the whole time and can be kept awake only with difficulty and only for short periods Between the eighth and twelfth day following the operation the patient dies

One has the impression that before the operation there was still a certain functional equilibrium of the liver in spite of the fact that the liver cells were greatly damaged and hampered in their function through the bile pressure It appears that the removal of the obstacle although obviously noxious has actually caused a total collapse of the liver function This is what I have called the "decompression syndrome" the "acute insufficiency of the liver" following decompression

collapse

of death There is no space to go into the details of the pathology of this incident \* Only measures to prevent and treat this

\* I refer to the report at the Congress of the American Association of Surgeons and to my forthcoming book

and the peripheral circulation began to weaken. Blood transfusion and glucose saline had no effect and the patient died on the sixth day.

Postmortem examination brought a surprising explanation. The colon from the hepatic flexure down to the rectosigmoid was found to be in a state of spastic contraction forming a solid band without a palpable lumen. The incarcerated ileum loop was completely recovered and there was no other pathologic finding. Obviously acetylcholine and prostigmine caused the spastic contraction of the sensitive colon and the slightly damaged small intestine did not react at all.

There is still another strong objection against the use of these bowel stimulants. What is usually called "paralytic ileus," that is to say, a bowel which is motionless and does not react after the normal time of recuperation, practically always indicates a beginning peritonitis. With the use of antibiotics, sulfa drugs, and anticolit serum there is some hope to bring under control a mild peritoneal infection, in its initial stage. However, the worst measure we can possibly think of is to stimulate a movement of the bowels which invariably would lead to a spread of the infection and hasten the fatal outcome.

Summarizing, we maintain that substances like prostigmine, acetylcholine, pitressin and the like in the postoperative course for the purpose of stimulating peristalsis should not be used. They are unnecessary in the normal course of recuperation and might be highly damaging in others, especially by stirring up a mild peritoneal infection. Troublesome distention of the bowel is relieved by introduction of an intestinal tube through the nose, followed by Wangensteen suction. The best way to provoke the first motion is by injecting 20 cc of pure glycerin into the ampulla recti. It acts as an irritant, provoking physiologic movement of the bowel as under normal conditions, as soon as the intestines have recovered from the operational injury.

**Leakage of Bile.**—Drainage of bile after cholecystectomy was believed to be almost inevitable in former times. It was attributed to the unsafety of the ligature of the cystic duct. In objecting to this opinion I wish to emphasize that a cystic duct provided it is properly ligated with silk in the right place, never leaks. A ligature with catgut, however, is not quite safe.

In many cases this bile leakage probably originates in the liver bed where the bile ducts in the liver bed can easily be injured when performing the classic cholecystectomy. In 1369 cases operated on with electrosurgical cholecystectomy and ligature of the cystic duct with silk I did not observe undesired drainage of bile in any case.

**Septic Diarrhea Following Cholecystectomy.**—In a certain number of cases we have observed some intoxication in early postcholecystectomy days which we have not found described similarly in the literature.

After an uneventful postoperative course for the first two or three days high temperature with chills and diarrhea sets in around the



sign in the postoperative course which usually appears between the third and fourth days following operation. This process of functional recuperation of the bowel takes place spontaneously without our help and encouragement provided that no serious intra abdominal incident like the development of peritonitis interferes.

Obviously, the surgeon is very anxious to have this signal of abdominal recuperation and safety and the question arises whether

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order to stimulate contraction and peristalsis? I feel very strongly that they should *never* be applied. The reason is as follows. When performing a laparotomy only a small part of the bowel suffers actual damage through exposure or mechanical handling. This is the part which is either the object of our operation hence lies within the operative field, or suffers through contact with abdominal pads. The other part of the bowels suffers no damage or at least is not damaged to the same degree. Recuperation of the different parts of the bowels, therefore does not take place as a unit and needs varying lengths of time. This is the reason why irregular bowel movements are often observed one or two days before regular peristalsis sets in. When a stimulant like prostigmine is injected the bowels do not react well as a unit. Only the undamaged loops react and sometimes with violent spasm while the damaged parts may remain completely insensitive. The effect of these stimulants therefore is not the promotion of a normal bowel movement but often is an increased *intestinal disorder*. When you whip two horses one of which is seriously ill the healthy one will jump but the ill one may completely break down. When sensitivity and ability to react return to a damaged intestinal loop it does not require any stimulant. The peristaltic wave initiating in a healthy loop will either pass over it when it has recovered or it will stop as before an obstacle when still damaged and paralyzed.

The following case although certainly unusual and rare nevertheless illustrates the ill effect which such stimulants may have

A man, 60 years of age heavy alcoholic was operated on under local anesthesia for an inguinal hernia with incarceration of a small loop of the small intestine. The abdomen was quite distended on the second day and the attending physician administered a duodenal tube and did not set in on the bowels on each of these days. Several enemata were administered but effect was not obtained. A

injury during operation, (b) when perforation of the gallbladder into the duodenum has occurred and after a cholecystectomy in which the hole in the duodenum was not closed carefully enough or has opened again, (c) when performing an anastomosis between the gallbladder and the duodenum (cholecystoduodenostomy) or an anastomosis between the common duct and the duodenum (choledochoduodenostomy) Such leakage from the duodenum must always be considered as a very serious complication leading within a short time to cachexia

through the leakage of a duodenal suture is the cause. The skin around the fistula becomes inflamed and ulcerous through the activity of the pancreatic juice. The patient loses weight rapidly.

The measures for dealing with such a duodenal fistula are (1) suction of the duodenal liquid, or better (2) tamponade of the wound with gauze soaked in olive oil, (3) suitable protection of the skin (thick layers of zinc ointment dusted with charcoal which is an excellent absorbent and inactivator of the pancreas enzymes), (4) parenteral feeding, (5) jejunostomy.

**Thrombosis.**—Thrombosis in a vein of the lower extremities must sometimes be feared in the postoperative course. In the majority of cases gallstone patients are adipose women with pregnancies in their histories. Varicose veins in the calves are frequent.

Prophylactic measures in endangered cases, especially when a history of previous thrombosis is present, should always be carried out. Both legs should be elevated and bandaged. Heparin and similar anticoagulants are definitely of value in preventing thrombosis or its progression. Prophylactic ligation of the superficial femoral vein might be considered.

times a day, which contains very little mucus and rarely traces of blood. Outstanding is its foul, offensive odor. The patient's temperature rises gradually to 103 or 104° F and he becomes increasingly prostrate and cachectic. Medicaments to stop these diarrheas are rarely successful and, in spite of transfusions and all other measures, death ensues within a few days after the first signs of general intoxication.

At postmortem examination the only pathologic finding is a diffuse enterocolitis. The mucous membrane is edematous and velvety red. The liver sometimes shows a slight degree of fatty degeneration but in some cases there are no pathologic changes at all.

I cannot give any satisfactory explanation of this development. The general aspect of the condition is that of a fatal typhoid or paratyphoid, in the third week. It has to be borne in mind that these patients were operated on not during an attack of acute gallbladder disease, but in an interval when there were no signs of a serious infection. In all of my cases of *paratyphus B* the colon was moderately inflamed and carried out as a straightforward

In one case *paratyphus B* in pure culture could be cultivated from the stool, in other cases only *B. coli*. It is worth recalling that in 1888

which he had performed  
were observed during  
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but, in contrast to the violent toxic diarrhea during the first few days after the operation, this diarrhea could be easily controlled by appropriate therapeutic measures (hydrochloric acid and pepsin in the first

indicating that after  
a in many instances

increases considerably the germs of the typhoid coli group. However, such cases of fatal septic diarrhea are rare.

**Bile Fistula.**—Bile fistula when persistent is caused in practically all instances by an overlooked stone in the common duct or by injury to the common duct (ligature). Overlooked stones that gave rise to the establishment of a bile fistula have been successfully treated by me and by other surgeons with the ether method. Sequelae of injuries to the common duct, so-called "benign strictures" are beyond the scope of simple postoperative treatment.

**Duodenal Fistula.**—This is observed (a) in case of an accidental

the anterior cortex takes on a gray translucency. The process goes on to the formation of an intumescent cataract with complete and uniform opacification. A remarkable feature is that, early in the formation of this type of cataract, treatment of the diabetes may clear up the lens,<sup>5</sup> though this is a rare outcome.

### COMPLICATIONS

ophthalmologists fear two  
Wiener and Alvis,<sup>6</sup>  
before operation, con-  
a proper diet under  
the guidance of an internist is sufficient, and insulin is rarely admin-  
istered. If the eye is not red, and if pressure on the tear sac does not  
result in the expression of infected material, local preparatory treat-  
ment is not necessary. They find that eye complications directly at-  
tributable to the diabetes are very rare following surgery.

Spaeth<sup>7</sup> pointed out that postoperative hemorrhages, especially into  
the anterior chamber, are not uncommon when the diabetes gets out  
of control. Duke Elder<sup>1</sup> states that in the average case operative treat-  
ment does not imply a bad prognosis provided the diabetes can be  
kept under control. Diabetes in itself is no contraindication to surgery.  
Benedict<sup>8</sup> believed, and rightly so, that increasing the dose of insulin  
before operation may lead to hemorrhage. It is interesting to note  
that before the use of insulin, Gifford<sup>9</sup> in 1911 pointed out that, after  
cataract extraction, 43 per cent of young diabetics lost their eyes as  
a result of postoperative infection. Although this may have been due  
to the nonuse of insulin, it should be remembered that the entire con-  
cept of the treatment of diabetes has changed. Wheeler<sup>10</sup> in 1916,  
reviewing a series of over two thousand cases, found that hemorrhages  
occurred in 5 per cent of nondiabetics and in 29 per cent of diabetics.  
In a recent report, Owens and Hughes<sup>11</sup> found in severe diabetics  
whose disease had lasted more than nine years, that following cataract  
extraction there was a significant increase of severe hemorrhage into  
the anterior chamber.

### CASE REPORTS

Recently at Montefiore Hospital we had the opportunity to do  
cataract extractions on two fairly young diabetics.

CASE I—A 34 year old woman who had arrested bilateral diabetes.

## CATARACT SURGERY IN THE YOUNG DIABETIC

A J LANCIENER, M D \*

It is well known that cataracts occur more frequently in diabetes. Two types of cataract develop with diabetes: the ordinary senile, and the true diabetic cataract.

The ordinary senile cataract occurs more frequently in diabetics than in nondiabetics. It appears at an earlier age and matures more rapidly in the diabetic.<sup>1</sup>

The true diabetic cataract is characterized by the following features: subcapsular changes are widespread and pathognomonic, it is bilateral, it tends to run a relatively rapid course, it appears mainly in young persons.

Kirby<sup>2</sup> made a study of the frequency of cataracts in diabetes. He found that 36 per cent of diabetics had clear lenses, whereas 64 per cent had opacities of some kind. In the latter group, 70 per cent were of the senile cortical type, 21 per cent were nuclear, 7 per cent were posterior cortical, and only 2 per cent were subcapsular or of the true diabetic type. The cataracts occurred more frequently in the moderate than in the severe cases. Although the severity of the diabetes did not increase the incidence of cataract, the duration of the disease was an important factor. Of the patients who had diabetes of more than five years, 64 per cent had cataracts, whereas only 25 per cent of those who had diabetes of less than five years had cataracts.

In the young, the cataract matures rapidly in the young, from a few hours to more usually several days and seldom takes more than a few weeks. In adults the progress of the cataract

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posterior cortex. Under the capsule, but very close to it, there is a layer of vacuoles interspersed with punctate and flaky white opacities. In the cortex there are water clefts and separation of the sutures. As the cataract progresses, the opacities become more diffuse and cloudy, white solid plaques forming in the posterior cortex, whereas

when the next dressing was done, there was no anterior chamber present. This may have been due to the fact that the patient was in a wheel chair and too active. He was put back to bed, and four days later the anterior chamber had reformed. The sutures were removed on the eighteenth postoperative day.

Thirty three days after the operation the patient complained of some pain and clouding of the vision of his left eye. This eye felt harder than the right. Tension Schiötz was OD 19 mm and OS 41 mm. Instillation of 2 per cent pilocarpine and 1 per cent eserine did not bring the tension down. Two drops of 0.1 per cent DFP was instilled into the conjunctival sac of the left eye. At the end of four hours the tension was down to 34 mm Schiötz and did not go any lower from that point. Instillation of 1 per cent pilocarpine brought the tension lower, so that two days later it was 23 mm Schiötz, and in the next four days it came down to 16 mm Schiötz. A rough refraction which consisted simply of placing a plus 12 lens before the left eye gave 20/70 vision. A more careful refraction with the correct sphere and cylinder undoubtedly will give much better vision.

### COMMENT

Both of these diabetic patients had premature senile cataracts, although it is possible that they may have started as true diabetic cataracts. This is especially likely in the second case in view of the rapid onset of the cataracts, which appeared three months after the diabetes was discovered.

The two complications most feared in diabetes hemorrhage and infection, had to be guarded against. The diabetes was brought under control and stabilized. Both patients were carefully checked for foci of infection. The operation was planned so that either a two stage or a combined operation could be performed. The determining factor as to which procedure would be followed was the amount of bleeding after the iridectomy. If there had been more than minimal bleeding, a two stage operation would have been performed but as there was no hemorrhage the combined operation was done. To reduce the chance of postoperative hemorrhage into the anterior chamber, the section was firmly closed with corneoscleral sutures.

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diabetic.

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it became 1/200 not improved by refraction. The corrected vision of the left eye remained at 20/70. Our examination revealed a mature senile cataract of the right eye, and an immature senile cataract of the left eye. The eyes were white, pressure on the tear sacs did not result in the expression of infected material, and no active foci of infection were found. Cataract extraction of the right eye was advised.

The operation was planned as follows. A complete iridectomy was to be performed, and if there was little or no bleeding, cataract extraction was to be done. If, however, there should be more than a minimal amount of bleeding, the cataract was to be extracted at a later date.

Operation was performed on April 22, 1946. Anesthesia was obtained by the instillation of 0.5 per cent pontocaine into the conjunctival sac and retrobulbar injection of 2 per cent procaine to which epinephrine had been added. Akinesia was produced by the use of the Van Lint method. After the insertion of a Stallard suture, a keratome section was made, followed by a complete iridectomy. There was no bleeding, so it was decided to continue with the cataract extraction. The section was enlarged with scissors, and the capsule was incised with a cystotome and a portion of it was removed with a Schweigger forceps. The lens was expressed, the suture tied, and two additional corneoscleral sutures were inserted. Recovery was uneventful. A dense secondary membrane formed. After dissection, vision was excellent.

**CASE II**—The second case was one of bilateral cataract in a man 46 years old who has Kimmelstiel Wilson's disease. Diabetes was discovered eight years

The same plan of operation was adopted in this case as in the first case. On May 8, 1947, a combined intracapsular operation was arranged for the left eye. There was no hemorrhage following the iridectomy, so the lens was delivered intracapsularly at the same operation, and the section was closed with double armed corneoscleral sutures. The first postoperative dressing was done two days later. At this time the anterior chamber was reformed. The patient had both his legs amputated some years ago and was very uncomfortable.

# TUBERCULOUS SALPINGITIS

## Report of a Typical Case

EDWARD C. VEPROVSKY, M.D., F.A.C.S.\*  
AND GEORGE SCHLAEFER, M.D.†

THE widespread use of sulfonamides and antibiotics in salpingitis of gonorrheal or pyogenic origin has greatly reduced the number of these cases requiring operative treatment in the chronic stage of the disease. Pyosalpinx, hydrosalpinx and chronic interstitial salpingitis are becoming less frequent as a result of adequate treatment of the acute stages of chemotherapy. The decrease in the frequency of gonorrheal and pyogenic salpingitis has caused a relative increase in the number of cases of tuberculous salpingitis seen at operation. Besides emphasizing the greater incidence and the clinical and pathological picture of tuberculous salpingitis, it is our purpose to discuss briefly the use of streptomycin either without surgery or as a preoperative or postoperative measure in its treatment.

## REPORT OF A TYPICAL CASE

L.L., a 28 year old colored married woman was admitted to Queens General Hospital on June 14, 1947.

History

Present Illness

Physical Examination

—The patient was an acutely ill, undernourished woman with a temperature of 101° F, pulse 90 per minute, respirations 22 per minute. The positive findings were limited to abdominal and pelvic examination. Her abdomen was slightly distended, doughy on palpation and she complained of slight tenderness in both lower quadrants on deep palpation. On pelvic examination there was a thick, creamy discharge from the cervix. The outlet was markedly relaxed.

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Queens General Hospital



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## COMMENT

This case presented a number of interesting diagnostic and therapeutic points which were more readily discernible in retrospect. The patient ran a septic course for six weeks in spite of repeated courses of the sulfa drugs and penicillin singly and in combination. Gonorrheal and pyogenic tubo ovarian disease usually respond to this therapy. Tuberculous disease does not.

Repeated chest x rays were negative for tuberculosis. Most cases of tuberculous salpingitis show no pulmonary involvement or a healed lesion. Pelvic tuberculosis is usually of hematogenous origin although occasionally it may follow direct extension from a tuberculous peritonitis or lymphatic extension from mesenteric lymph nodes. A negative chest plate does not rule out a tuberculous salpingitis and a positive x ray is not diagnostic although it should make one suspicious.

The white blood count was not elevated and repeated blood counts showed a moderate leukopenia with an increase in the lymphocyte count. This is usually seen in tuberculosis in contradistinction to the leukocytosis in gonorrheal or pyogenic pelvic inflammatory disease associated with fever.

On abdominal and pelvic examination the abdomen had a doughy sensation and was not as tender as one finds in the usual case of pelvic inflammatory disease. We have frequently elicited this doughy sensation in cases of pelvic or intestinal tuberculosis.

The sedimentation rate was elevated in this case. In uncomplicated tuberculous salpingitis the sedimentation rate is normal although it is elevated if there exists a concomitant active tuberculous lesion.

Leukorrhea is present in most pelvic infections. Several years ago one of us made vaginal smears in 150 tuberculous patients who were suffering from leukorrhea. The smears were examined by Dr. Petroff of Sea View Hospital for tubercle bacilli and none were found although three of these patients were found to have tuberculous salpingitis at operation.

The amenorrhea in this patient was associated with a weight loss of 20 pounds. The amenorrhea was not due to the tuberculous process.

and of recognizing it at operation cannot be overemphasized since

proceeding with a case would leave a focus of infection which would cause future symptoms. In the case reported the endometrium was not involved in the tuberculous process although such involvement occurs in about 50 per cent of the cases. Since both ovaries and tubes were removed the uterus could serve no useful purpose and was also removed.

and there was a third degree laceration of the perineum The uterus tubes and ovaries were matted together and indurated There were bilateral tubo ovarian masses the one on the left side being about 8 cm in diameter the one on the right smaller The cervix was lacerated

disease (A chest x ray several weeks postoperatively was also negative ) Repeated blood cultures were sterile Vaginal smears and cultures were negative for gonococci

conservative therapy led to the impression that she was suffering from a chronic tubo-ovarian disease probably on a tuberculous basis and that operation offered the patient her only chance of recovery

Operation -At laparotomy there were extensive thick adhesions binding the uterus adnexa small and large intestine into a large mass This was separated by

the abdominal cavity was drained the patient

genitalia revealed

undilated  
bilateral  
ovarian  
8 cm in

## CUTIS GRAFTS FOR REPAIR OF INCISIONAL AND RECURRENT HERNIAS

HANS MAY, M.D., F.A.C.S.\* AND R. GAYLE SPANN, M.D.†

OCCASIONALLY it is desirable to reinforce defective tissue with some stronger tissue in hernia repairs. This is especially true in the case of recurrent hernias and incisional hernias. The use of fascia for this purpose, usually in the form of strips of fascia lata, is well known. It seems to us that the cutis graft has definite advantages over fascia for use in these repairs.

Loewe<sup>1</sup> in Germany appears to be the first to use the cutis graft. Rehn<sup>2</sup> deserves credit for popularizing the method. Uihlein<sup>3</sup> reported the use of the cutis graft in Rehn's clinic along with histologic studies on cutis grafts. Cannaday<sup>4</sup> in 1942 first reported use of the method in this country. He first reported fourteen cases including inguinal and incisional hernias, uterine suspension and bone grafting. Subsequent reports of his have included repair of dural defects, femoral artery defects and various orthopedic procedures as well as hernia repairs. Peer and Paddock<sup>5</sup> had also reported histologic studies on implanted

Loewe, Uihlein and Uihlein state that Rehn used a skin grafting knife to remove the skin after the cutis graft was placed over the wound site after the cutis was removed.

Early objections were raised that the buried glandular structures would cause cyst formation. This has not proved to be a clinical objection. Peer and Paddock examined dermal grafts implanted seven days to one year and found disappearance of sebaceous glands and hair follicles and degenerative changes in the sweat glands. Mair,<sup>9, 10</sup> obtained similar findings. Whole human skin had undergone metaplasia until it was grossly similar to fascia after three months, but all elements of the skin could still be identified microscopically. He also

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To date no reports on the use of streptomycin in the treatment of pelvic tuberculosis have been published. There are several reasons for this, namely, the difficulty in making a positive diagnosis preopera-

tubulous salpingitis. We suggest that cases of salpingitis which do not respond to the sulfonamides and penicillin and in which a positive endometrial biopsy is obtained be given a course of streptomycin. After

be di-  
tinued

every week so that changes in the pelvic condition may be judged.

In those cases in which a positive endometrial biopsy is not ob-

the pelvis at the time of operation. It is sometimes not possible to remove all the tuberculous lesion without injury to the bowel or bladder and it becomes necessary to leave a small portion of tuberculous

make the diagnosis of tuberculous salpingitis extremely probable. The

all of the peritoneum generally may be studded  
with a cheesy  
characteristic

is that in the tuberculous tube there is a tendency for the fimbria to remain everted and the orifice patent, even though the tube is distended. This is in contradistinction to the usual chronic gonorrheal salpingitis, in which the fimbriated end of the tube is closed and bulbous and the fimbriae inverted and obliterated.

### CONCLUSIONS

1. Cases of chronic salpingitis not responding to sulfa drugs and  
olosis of which a typical

tuberculous salpingitis  
is not positively or at

been

4. The use of  
briefly discussed

studied rabbit skin buried for five months under tension. At that time it disappeared and was

One of us (H M) has used cutis grafts satisfactorily in the correction of nasal defects, tendon defects and joint repairs. However, this paper is concerned only with calling further attention to a method of hernia repair which we feel is not so widely known as it deserves.

Cutis grafts are applicable anywhere fascial grafts or sutures have been advocated. The cutis graft has the advantage of availability in any quantity, size or shape needed. It is easily handled. It is exceedingly strong in all directions of pull in contradistinction to fascia where most of the strength is in the longitudinal direction of its fibers. The cutis graft takes better when sutured under tension which is imperative in hernia repairs. The tension has been found to stimulate metaplasia. The cutis, having a higher rate of metabolism and being less inert than fascia, becomes more readily replaced by live connective tissue with blood vessel and nerve supply.

#### TECHNIC

The technic which we use will be described. The donor site is prepared the night before operation by shaving, scrubbing with soap and water for ten minutes, and removing any remaining oil with ether. Then alcohol is applied and the site is covered with a sterile towel. Except for shaving, this procedure is repeated in the morning.

In the operating room spinal or inhalation anesthesia is given. Alcohol is applied to the donor site, the skin is again dried with ether and cement is applied. Cement is applied to the drum of the dermatome, a sheet of nylon is applied over the cement and another layer of cement is repainted on the nylon. The epidermis is then raised from the donor site in a sheet 0.008 to 0.010 inch thick. The epidermis is left hinged at one end, and the cutis graft is outlined by incising through the rest of the skin down to the subcutaneous fat. Long sutures are placed through the cutis at each corner and along the edge of one end and it is rolled upon a gauze roll, cutting all the fat off

of the nylon-covered epidermis are sutured in their former position. Pressure dressing is applied. (This dressing is changed in one week and the sutures are removed.) The cutis graft is placed between cool

and the cutis graft is sutured upon the defect of the

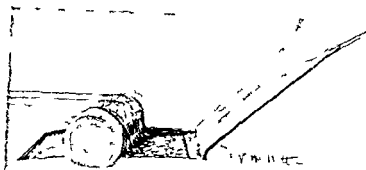


Fig 143—A thin epidermis graft is raised and hinged. The cutis beneath is removed.

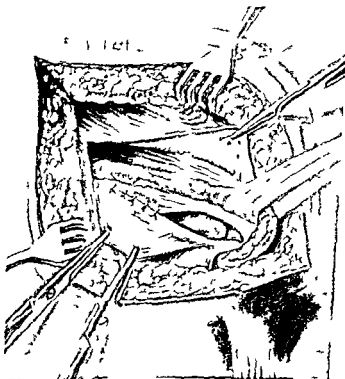


Fig 144—Inguinal hernia. The cord is held med ad, the fascia of the external oblique muscle is retracted on either side, the conjoint tendon and free border of the internal oblique muscle is sutured to Poupart's ligament. The lower part cannot be closed on account of lack of tissue.

not be satisfactorily sutured to Poupart's ligament. The case illustrated in Figures 144 and 145 is an example of this type. If there is no good tissue to suture the upper edge of the graft to, it is better to imbricate the aponeurosis under the cord than to suture the graft over the aponeurosis. Care must be taken in all cases to suture the graft under tension to the pubic tubercle, and make the split to go around the cord at the internal ring. Some illustrative cases are reported.

In the case of incisional hernia the fascia is dissected clean for 1 inch surrounding the hernial ring. The excess peritoneum is excised and it is closed. The fascia is closed as much as possible with cotton or wire. The cutis graft is then sutured in position over the closure

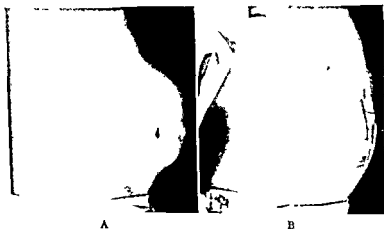


Fig 146—Large incisional hernia repaired by Mayo technic and cutis graft. For details see Case I.

surrounding the closure for 1 inch. The subcutaneous tissues are then sutured down on the graft, closing all dead space. The skin is closed and a tight dressing is applied (Fig 146).

#### CASE REPORTS

**CASE I** (Hosp No A33587 Fig 146)—B.M., a 65 year old white man, was admitted to Lankenau Hospital in December 1944 at which time a cholecystectomy through a right upper rectus incision was performed for calculous cholecystitis. Postoperatively a partial dehiscence of the wound occurred with no evisceration.

Follow up examination revealed an incisional hernia. This was repaired with wire in September 1945.



anterior wall of the inguinal canal (Fig 145) One end of the graft is sutured to the periosteum of the pubic tubercle one edge to Poupart's ligament the other edge is sutured to the fascial covering of the conjoint tendon and the remaining end is split so that the spermatic cord as it emerges from the internal ring will fit into the "V" in the graft This should fit snugly but not strangulate the cord

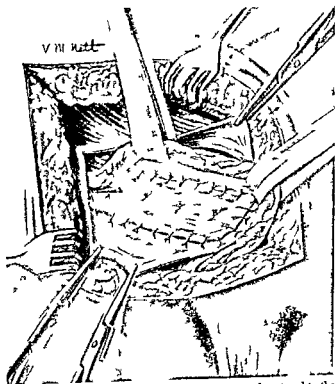


Fig 145 The defective area is covered with a cutis graft sutured to the periosteum of the pubic tubercle one edge to Poupart's ligament the other edge to the fascial covering of the conjoint tendon and the remaining is split at point of emergence of the spermatic cord from the internal ring

The cord may then be laid back upon the graft the aponeurosis of the external oblique repaired over the graft and cord and the skin closed over it In certain cases it is felt that more support of the graft is needed and the aponeurosis of the external oblique is sutured directly over the graft and under the cord which then comes to lie subcutaneously as in the Halsted herniorrhaphy In still other cases it will be found that the conjoint tendon is so attenuated that it can

not be satisfactorily sutured to Poupart's ligament. The case illustrated in Figures 144 and 145 is an example of this type. If there is no good tissue to suture the upper edge of the graft to, it is better to imbricate the aponeurosis under the cord than to suture the graft over the aponeurosis. Care must be taken in all cases to suture the graft under tension to the pubic tubercle, and make the split to go around the cord at the internal ring. Some illustrative cases are reported.

In the case of incisional hernia, the fascia is dissected clean for 1 inch surrounding the hernial ring. The excess peritoneum is excised and it is closed. The fascia is closed as much as possible with cotton or wire. The cutis graft is then sutured in position over the closure.

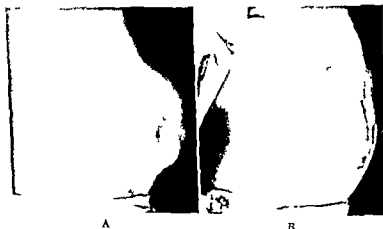


Fig 146—Large incisional hernia repaired by Mayo technic and cutis graft. For details see Case I.

under tension using cotton sutures. Several sutures are placed through the graft into the underlying structures to insure close approximation of the graft and these tissues. The graft covers all the cleaned fascia surrounding the closure for 1 inch. The subcutaneous tissues are then sutured down on the graft, closing all dead space. The skin is closed and a tight dressing is applied (Fig 146).

# CASE REPORTS

CASE I (Hern. No. 100707, D. 10)

In November 1945, an abscess of the abdominal wall just lateral to the herniorrhaphy was incised and drained.

In April 1946, he returned with the incisional hernia larger than ever. It measured 4 by 6 inches. At this time the hernia was partially closed with the Mayo technic, after a difficult task of freeing the incarcerated small bowel which was inadvertently opened and repaired in one place. A cutis graft was taken from the left abdominal wall and sutured over the fascial closure. He was allowed to walk on the twenty-second postoperative day and discharged on the twenty-seventh postoperative day.

Follow up examinations at three, six and nine months showed no evidence of recurrence and relief of all symptoms which were present before the repair.

CASE II (Hosp. No. 16018) —JW, a white man, 26 years of age, was first

was performed

A second recurrence of the right inguinal hernia was found in Follow up Clinic in October 1945. He was readmitted in January 1946.

suture was used throughout.

The postoperative course was uneventful. He was out of bed on the twentieth day and discharged on the twenty-third postoperative day.

Follow up examination at three months and at nine months after operation showed no sign of recurrence.

CASE III (Hosp. No. 491103) —FC, a white woman, 54 years of age, was

being struck by an automobile, her right arm and cerebral injured. She was hospitalized for three weeks.

Two months after discharge from the hospital, she began complaining about a lump above the right iliac crest which was difficult to demonstrate because of adiposity.

In October 1945 a hernia above the iliac crest just anterior to the quadratus lumborum muscles was repaired with a cutis graft taken from the right thigh. The bone was exposed to the periosteum of the ilium. She was allowed to walk on the twenty-first postoperative day.

Follow up examination at three months and at nine months showed no evidence of recurrence.

CASE IV (Hosp. No. 5901) —BJJ, a 54 year old white woman, was readmitted to this hospital in September 1946 for repair of an incisional hernia of the lower

abdominal wall. She was first operated upon in 1926 when a hysterotomy was done. The wound became infected and was drained and a hernia resulted. This had been repaired five times prior to this admission. The hernia of the right lower rectus region was the size of a baby's head. It was necessary to try further repair due to recurrent symptoms of partial obstruction.

The cutis graft was taken from the left side of the abdomen. The excess sac was excised, the peritoneum closed, the fascia was closed with wire, and the cutis graft was sutured over the closure with the subcutaneous tissue sutured to the

donor site instead of a thigh. The patient was not a first class operative risk and

on therapy and an attack of gallbladder con-

done on November 25, 1946. The sinus tract extended to the surface of the cutis graft which seemed to be strong. A piece was taken for examination.

There had been no evidence of recurrence of the hernia in this short time.

**CASE V—M.P.** a 61 year old woman was operated upon in this hospital in April 1946. A right direct and indirect or pantaloon type of hernia was repaired by closure of the inguinal canal.

The hernia recurred in five months. She was readmitted to the hospital in February 1947. At operation a large defect was found surrounded by Poupart's ligament below, the conjoint tendon above and the pubic tubercle medially. A

### COMMENT

We have not hunted cases on which to use the cutis graft technique but rather have used it in cases which presented problems as to obtaining a satisfactory hernia repair. We have continued to use the established methods of hernia repair in all cases in which experience has led us to expect good results. It is too early for any statistics as to complications and recurrences but we are favorably impressed with the cutis graft as a closure for serious abdominal wall defects.

The main advantages of the method are its constant availability in any size or shape, its strength in all directions of pull, and the viability of the buried graft. The disadvantages are the increase in preparation for operation and the increase in time of the operation which is a factor if the patient has intestinal obstruction, or is a subnormal operative

risk for any other reason. Another disadvantage is the occasional delay

trouble. Case IV presents one objection to the use of whole skin from over large hernias. The skin over such areas is a poor structure. On the other hand, it will prove a less prolonged procedure for poor risk patients. More experience is needed to make a final evaluation of the problems, but we are certain that the cutis graft will take an important place in the repair of recurrent and incisional hernias.

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## MODERN TRENDS IN SURGERY OF THE COLON

MOSES BEHREND M D FACS FICS\* AND  
ALBERT BEHREND M D FACS FICS†

THE truth of the aphorism of the late John B. Deaver, Cut well sew well and get well is repeatedly demonstrated in surgery of the colon

We feel that one of the greatest advancements in surgery of the colon of the past few years has been our ability to eliminate the obstructive type of resection also known as the Mikulicz operation. It has not been necessary to perform this type of operation even in the

struction and to prepare them so that primary definitive surgery can be done. In a few cases where obstruction has been severe preliminary cecostomy has been necessary followed by resection and anastomosis within two weeks. It has been five years since we have performed the classical obstructive resection or Mikulicz operation.

In all fairness it should be stated that our results with the operation of obstructive resection were good and the mortality was not higher than that observed with the operation now performed namely resection and immediate anastomosis. However two recent reports indicate that the obstructive resection has a higher mortality than resection of the colon with immediate end to end anastomosis. Gibbon and Hodge report that the mortality from the exteriorization operation is twice as great as from resection with end to end anastomosis. White

temporary colostomy and the lengthy hospitalization required because of the staged operations.

The modern treatment of lesions involving the large bowel depends on the location of the lesion and requires individualization for each patient. When the portion of bowel to be resected lies between the cecum and the rectosigmoid junction resection with primary anas

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From the services of the Jewish and Mount Sinai Hospitals Philadelphia

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tomosis can usually be done and is superior to any other method. Such resection is performed without any preliminary ileostomy, appendicostomy or colostomy, unless there is complete intestinal obstruction. When the area to be removed lies beyond the rectosigmoid junction we feel that the abdominoperineal operation of Miles with a permanent abdominal colostomy is the procedure of choice. This operation has also been performed in patients who have come to the hospital moderately obstructed. The use of decompressing measures mentioned above and irrigating enemas from below has enabled us to perform the Miles operation without preliminary colostomy.

and a portion of the transverse colon must be removed and an anastomosis performed between the terminal ileum and the transverse colon. This is usually a side-to-side anastomosis, but frequently an end-to-side or an end-to-end anastomosis may be possible. The end

simplest of all methods of joining two pieces of bowel. If C. W. Mayo's admonition is followed of cutting the ileum obliquely, additional width of the ileal stoma is obtained.

When the lesion lies in the transverse colon one must pay great attention to the relation of the middle colic artery to the tumor. If it is necessary to divide the middle colic artery in order to remove an adequate portion of the diseased bowel, a wide resection involving the hepatic or splenic flexures is indicated in order to assure adequate

affected portion of the colon is always followed by immediate end-to-end anastomosis.

Recognition of a carcinoma in the splenic area may be difficult because of the failure of x ray to localize a lesion in this area. At times we feel that too much dependence is placed upon x ray examinations. One must remain cancer conscious and never hesitate to operate when there is any suspicion that a tumor of the large intestine is present. This is particularly true in the splenic area where tumors may be present but "silent" for a long time. Mobilization of this area is the most difficult in the entire colon but can be facilitated by the use of spinal anesthesia and adequate incision. Several inches of normal bowel are removed on each side of the lesion and an end-to-end anastomosis is performed.

From the viewpoint of the surgeon the most favorable area for resection is the descending colon down to the rectosigmoid junction. Fortunately a high percentage of colon tumors are found in this area. The present day tendency is to remove wider and wider segments of bowel and mesentery and although some men advocate removal of the splenic flexure for any lesion lying in the descending colon we have not found it necessary to be so radical. When resection is carried out for a lesion at the rectosigmoid junction difficulty may be encountered with a primary anastomosis because of the short distal piece of colon. Here again adequate incision and relaxation together with blocking out the rest of the abdominal viscera by abdominal packs is important. These preliminaries are essential to the accurate sewing which is required in performing a primary anastomosis in this situation.

Several years ago one of us used the closed method of anastomosis and followed the principles laid down by Kehr. However we found wounds became infected even with this method and some patients died of hemorrhage.

These were the days before the patient was prepared with sulfonamides, penicillin and streptomycin so that infection was much more common even using the aseptic method than it is today. Now the aseptic method of suture is not necessary and a more careful hemostatic and accurate anastomosis can be performed by the open method.

#### PREOPERATIVE AND POSTOPERATIVE CARE

One dislikes to be dogmatic in the practice of medicine but it is inevitable that years of experience help to formulate certain conclusions. At the same time one must be liberal enough to utilize new developments in the ever changing science of surgery and medicine. It is difficult to understand why some of the masters and leading teachers in the art of surgery do not avail themselves of the improvements which have developed in the technique and preparation of the patient. It has been demonstrated to our satisfaction and to the satisfaction of many others that the preoperative and postoperative plans as outlined below have been invaluable aids in lowering the mortality and above all the morbidity of colon operation.

**Preoperative Care**—Our preoperative plan is as follows:

1. An ounce of castor oil is administered shortly after the admission of the patient to the hospital.
  2. Succinylsulfathiazole (sulfasuxidine) 0.25 gm per 1 lb of body weight.
  3. " "
  4. " "
- intrav. " "
5. Blood transfusion is used as required preoperatively. At the time of operation 1000 cc of blood is always available.



6 The gastrointestinal tract is decompressed by the Wangenstein method, using either the Levin or Miller-Abbott tubes

Partial obstruction can almost always be relieved by these methods in conjunction with colonic irrigations. In some instances even complete obstruction is benefited, but in such cases colostomy must be performed if the obstruction is unrelieved in twenty four hours because of the danger of bowel perforation. However, the use of this routine results in the need for fewer colostomies

7. The preoperative diet is limited to sweetened liquids, fruit juices and gelatin which are given every two hours. We formerly used a low residue diet at the outset of the preparation and stopped it forty-eight hours before operation, but even with this, we found that occasionally too much residue remained in the colon

8 Prothrombin time, serum protein and albumin globulin ratio are checked in every case. Vitamins B, C and K are usually given

9 A Levin tube is always placed in the stomach just prior to operation if not previously required for the relief of obstruction

This plan of preparation has been adopted because it has never failed to produce a practically empty colon. Occasionally one finds a little slimy mucus on sectioning the bowel, but the bacterial count of this material is low. Consequently, an open anastomosis can be done with a minimum risk of infection

P . . . C . . . . . as follows

removal of the tube on the second to fourth postoperative day

2. A rectal tube is inserted every four hours for a period of twenty minutes until feces pass. Occasionally we dilate the anal sphincter digitally before the patient leaves the operating room. These measures prevent the accumulation of gas in the rectum and sigmoid in the early postoperative period.

3 Parenteral administration of glucose, saline and amino acids is maintained until the patient is able to take a sufficient amount of fluid by mouth

4 Blood transfusion is given as indicated

5 Penicillin, 50 000 units, is given intramuscularly every three hours for from five to seven days, depending upon the febrile reaction of the patient.

6 Enemas are usually unnecessary. Flatus is commonly passed twenty four hours after operation and the bowels move spontaneously by the fourth or fifth day. Occasionally a six ounce olive oil enema is required to facilitate the first passage

7 When nausea is not present postoperatively, patients are given sulfasuxidine in the same dosage as preoperatively until the bowels move normally and the temperature is normal

8 Ambulation is encouraged from twenty four to forty eight hours after operation

### TECHNIC OF OPERATION

The technical difficulties of colon operations become minimal with proper relaxation and exposure. Relaxation is obtained by the use of

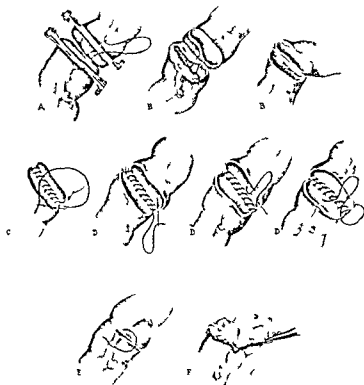


Fig 147 —A First suture of linen thread on adjacent sides of the mesentery of the colon B Interrupted mattress suture on an atraumatic needle with catgut the knots of which are sewed C and D the Connell suture E serous surface F (Behrend M J A S 1945)

spinal anesthesia which may be supplemented by intravenous pentothal sodium in the nervous patient. Exposure is obtained by a right or left pararectus incision of adequate length depending on the loca-

tion of the lesion. When portions of the right or left colon are to be resected, dissection is aided by mobilization of the lateral peritoneal fold followed by incision and dissection of the medial peritoneal covering of the mesentery. Following these two maneuvers the important blood vessels and ureters should be readily identified.

After the lesion of the colon is mobilized, clamps are placed above and below at a safe distance from the tumor. The remainder of the peritoneal cavity is walled off by judiciously placed packs. Four



Fig. 148.—There is evidence of an anterior tumor mass pressing on the sigmoid colon. Patient was 14 years old.

clamps in all are used of the Stone or de Martel type. The Bovie ap-  
 1 1 to cover the gut between the clamps following  
 anastomosis is performed  
 se of the preparation as  
 outlined above. The first suture in a colic operation is a posterior  
 seroserous suture of linen thread or silk. This may be interrupted or  
 continuous. Posteriorly there are two additional rows of suture, one  
 an interrupted mattress suture of fine catgut with the knots tied within

the bowel and the third a continuous row of catgut joining the two mucosal and submucosal layers. This suture is continued anteriorly as a Connell suture which closes the angles and the anterior walls of the colon. A seroserous suture of interrupted linen thread is used anteriorly. Finally, a fat tab is placed over the field of operation (Fig 147).

### AGE FACTOR IN CANCER AND SARCOMA OF COLON

Cancer and sarcoma of the colon do not respect any age, as indicated in the following histories



Fig 149—X ray reveals carcinoma of the transverse colon. This was confirmed at operation. Patient was 85 years old.

The youngest patient we have operated upon was a 14 year old boy. He had complained of abdominal symptoms for at least two or three years.

He died four months after admission to the hospital.

Our oldest patient operated upon was a woman 85 years of age. She was admitted to the Jewish Hospital early in July and was operated upon on August 4, 1947. She had symptoms of obstruction. X ray showed an occlusion in the

developed bilateral infarcts for which huge doses of penicillin were given. While convalescing from these attacks another infarct developed in the lung.



Fig. 150—Lesion of the sigmoid colon was revealed by x ray. Patient was 83 years old.

*Comment*—The last two patients may be considered together. They were both 80 years of age. The latter was in fine physical condition while the other was in poor health, emaciated and weak. Carcinoma of the colon was located in the transverse colon in one case and the sigmoid flexure in the other. The tumor in the former caused intestinal obstruction, while in the latter, daily hemorrhages were the rule. Both

made fine recoveries, but a few days after operation they developed hemorrhages from the colon with a lowered prothrombin time. Vitamin K intramuscularly stopped the bleeding promptly in both cases. The site of operation was not drained nor was a tube colostomy used in either case. Early ambulation was used with beneficial results.

### SARCOMA OF THE COLON

Sarcoma of the colon in addition to cancer may require resection followed by a one stage open anastomosis. Melanosarcoma of the colon is a rare condition. About thirty cases in all have been reported. These

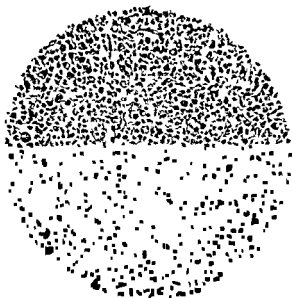


Fig. 151—A malignant melanoma of the sigmoid was found. Microscopic examination showed an extremely anaplastic growth with cells of all shapes and sizes with considerable pigment present.

patients do not present characteristic symptoms, but follow the picture as so often seen in cancer of the colon. The average age is 45 years, although Rankin and Chumly reported one in a child 11 years of age. Diagnosis is rarely made except at autopsy, and the microscopic examination of the specimen after resection of the colon. A case in point is reported as follows:

The patient E.M., 53 years of age, suffered from abdominal distress accompanied with considerable pain for at least two years before he consulted his family physician. Almost immediately afterward he was hospitalized. The usual preopera-





Fig. 152.—Benign polyp of cecum x-ray findings.



Fig. 153.—Benign polyp of cecum, gross pathological specimen (cecal)



tive care consisting of sulfa drugs, colonic irrigations glucose and blood transfusions was administered. Examination of the liver showed many metastases but because of the obstructive symptoms it was deemed advisable to perform a formal operation on the colon. At the time of operation the tumor to all intents and purposes felt like a carcinoma. The operation of resection and end-to-end anastomosis was performed. The patient did well for almost a week. We instituted early ambulation. About the seventh or eighth day a fistulous tract developed. The anastomosis broke down and there was expulsion of feces followed by disruption of the wound. Following this the patient gradually declined and died about three weeks following operation.

The pathological report stated that a malignant melanoma invaded the sigmoid colon. Microscopic examination showed the growth extremely anaplastic. It consisted of cells of all shapes and sizes with considerable pigment present (Fig 151).

*Comment*—Unfortunately, this was the type of patient who did not reveal his symptoms to his family physician until two weeks before the admission to the hospital. The lesion was an extensive one. Numerous metastases were found in the liver. After the rupture of the abdominal wound, the patient lost ground.

### POLYPS OF THE COLON

Polyps of the colon are often forerunners of carcinoma of the colon. The symptoms may be the same as those of cancer, depending on the location of the polyp. If the polyp is large enough, obstructive symptoms may occur. In the case reported below, the radiologist inclined towards the diagnosis of benign polyp in the region of the ileocecal valve. At the time of operation upon this patient the cecum, ileum and surrounding structures were indurated, giving one the impression that a carcinoma really existed. The history is as follows:

SF., 33 years of age, was admitted to the Jewish Hospital on June 7, 1947. One year ago the patient had had pain in the right iliac region, and was then operated on for an undescended testicle; the appendix was removed at the same time but the pain continued. X-ray diagnosis at the time of admission was granuloma of small bowel and cecum of the skip pattern (Fig 152). A one-stage resection of the cecum, ascending colon and part of the ileum was performed on June 14, 1947. The ends of the ileum and cecum were closed; a lateral anastomosis was used to complete an ileocolostomy. Pathological diagnosis revealed a chronic

	benign cecal polyp
	ed glucose 89 mg
"	gm per 100 cc
"	u. mm., polymor
"	er cent filamented

*Comment*—It is probable that the polyp with the surrounding pathology was present at the primary operation performed a year ago. The original pain persisted. An x-ray revealed a defect in the region of cecum. The radiologist leaned strongly in favor of a benign lesion. At operation the mass felt like cancer of the cecum. The pathologist,

ing obstructive symptoms. Such was the case in the patient about to be reported. Resection of the colon is rarely performed.

A M., 39 years of age, was admitted to the Jewish Hospital on August 24, 1947. The patient was well until four years ago when he developed pain in the left lower iliac region. Since that time he has had several hospitalizations due to pain. In the last attack he had symptoms of intestinal obstruction. Notwithstanding his condition, he gained weight. Examination revealed a fat abdomen with no masses or tender spots. X-ray revealed several diverticula, one of which had perforated (Fig 154). On August 28, 1947, under spinal anesthesia, the sigmoid was found



Fig 155—Diverticulitis with perforation, gross pathological specimen.

found and removed.

diverticulitis.

*Comment*—This was a very interesting case because most cases of diverticulitis are not operated upon. Persistent pain and discomfort were the prominent symptoms. These symptoms and the attack of in-

## ONE STAGE VERSUS TWO STAGE OPERATION ON THE COLON

Since the Mikulicz operation has been practically abandoned on our service, the preference for one stage operations on the colon has been emphasized because the one stage operation with resection and

however, reported a benign polyp with an inflammatory reaction around it

*Follow-up*—The patient is reported well by his family physician. Except for occasional bouts of diarrhea, the patient suffers no discomfort.

### DIVERTICULITIS OF THE COLON

Most cases of diverticulitis of the colon are treated medically. Diet and medication usually suffice to keep them in a fair state of health.



Fig. 154—Diverticulitis with perforation, x ray findings

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various loops of intestine may become attached one to the other caus

cited are so great that it has been replaced by other simpler and less time-consuming procedures. The newer procedures have been made possible by better knowledge of the physiology, anatomy and the application of chemotherapy before and after operation. This knowledge is applied in the preoperative and postoperative precautions which must be adhered to so that the best results may be obtained. The best operation dependent upon the anatomicopathological location of the tumor has been described. We are partial to a one stage resection and primary anastomosis of the colon when the lesion is proximal to the rectosigmoid junction. Even here, when the colon and lesion can be mobilized, it may be possible to perform this operation. Beyond this point a Miles operation is indicated.

for cancer of the colon, our oldest patient was 85 years of age. Another malignant lesion which may attack the colon is sarcoma. This is a rare condition. We have reported a case of melanosarcoma of the colon exhibiting the same symptoms as those found in cancer of the colon.

We have also included a case of benign polyp in the region of the ileocecal valve causing intermittent pain. The radiologist was under the impression that a benign growth was present. At operation, however, induration was marked. To the palpating finger, the hardness and resistance of the tumor suggested carcinoma. The pathologist dissipated these suspicions, reporting the growth as a benign tumor. A one stage resection was performed with an immediate lateral anastomosis of the ileum and colon.

Resection and end-to-end anastomosis for diverticulitis of the colon is an uncommon operation. Patients suffering from diverticulitis may be carried along for years with medical treatment. When perforation or obstruction occurs, surgery is necessary. Such was the case in the patient reported above.

### CONCLUSIONS

1. The Mikulicz operation has practically been discarded from our service.
2. A one stage resection with open end to end anastomosis has replaced it in all tumors of the colon up to the rectosigmoid junction.
3. Below this point a Miles one stage abdominal perineal operation has been used in the majority of cases.
4. Strict attention to the

open end to-end anastomosis requires but one procedure. The stay in the hospital of the patient is at least three or four times as great with the Mikulicz operation as compared to the one stage procedure. In cases of carcinoma of the rectum we abandoned the two stage procedure exactly ten years ago. These were unnecessary operations and subjected the patient to much more surgery than was necessary. The one stage abdominoperineal or occasionally the one stage pull through operation is preferred to any two stage procedure. The same may be said when carcinoma affects the cecum and ascending colon. Here almost insuperable adhesions may be encountered after the first stage rendering the second operation more serious than the first.

anastomosis the mortality was 38 per cent while in the multiple stage operation it was 153 per cent. In carcinoma of the transverse colon the mortality with exteriorizing the lesion was 20 per cent whereas with a primary anastomosis it was 111 per cent.

We formerly considered the Mikulicz the safest operation to perform on the colon. This opinion is still shared by many prominent surgeons who refuse to perform a one stage resection and anastomosis. Our mortality from the Mikulicz operation was 45 per cent. Three of

colon found at the time of the primary operation. These cannot be in justice charged against the Mikulicz operation. Our mortality following the one stage resection with end to-end anastomosis is 53 per cent. In a paper read before the American Medical Association on June 15 1944, there were no immediate deaths following this operation. One patient a colored woman died two weeks after she was discharged from the hospital from apoplexy due to high blood pressure. The other patient, a white woman, 72 years of age, died of peripheral gangrene.

#### SUMMARY

We have attempted to portray in this paper the modern methods

## SUPPLEMENT TO THE SYMPOSIUM ON BLOOD VESSEL SURGERY

### PHLEBOGRAPHY OF LOWER EXTREMITY

DAVID C. BULL, M.D.\*

VISUALIZATION of veins of lower extremities by injection of radio opaque media is not new—it was first done by Berberich and Hirsch in 1923. Others have used it for various purposes as the demonstration of downward flow of varicosis by McPheeters and Rice and of details like communication by Edwards. Interest reached its crest after the publication of Dougherty and Homans in 1935 who demonstrated thrombosis and studied normal veins. Neuhof a few years later stated that by routine use of phlebography in cases of unexplained temperature on the surgical service of Mount Sinai Hospital, New York femoral phlebitis was demonstrated with astonishing frequency. Enthusiasm was dampened, however, by Allen in 1938 who found the results unsatisfactory in one third of his cases due to artefacts.

Today the diagnosis of femoral phlebitis is usually made on clinical evidence. False positives in phlebography are inevitable but if by phlebogram a normal deep vein shadow is demonstrated the mistake can be corrected and the patient spared some vigorous treatment or an operation. This indication alone justifies maintenance of interest in the x ray visualization of veins.

The technic varies considerably in different institutions and ours has changed from that originally used. We install a Lindeman needle cannula on the ward usually in the internal saphenous vein at the ankle. Sometimes the external saphenous vein beside the Achilles tendon is used. Occasionally we have been unable to introduce the needle without exposing the vein. With the obturator in place the cannula can be left in the vein indefinitely. Depending on the vein used the patient is placed supine or prone on the x ray table with the upper one half of the field over the Bucky diaphragm and the lower over a simple cassette. Two tubes are used each at the usual 32 inch distance. Forty cubic centimeters of 35 per cent diodrast are injected rapidly and the distal exposure is made. The cassette is immediately withdrawn and the second tube exposure made within five seconds of

\*From the Department of Surgery, Mount Sinai Hospital, New York.

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enth and eighth decade because these patients have a convalescence as good as those in the younger groups

6 We prefer at all times a one stage operation in preference to a two stage procedure

7 *A rare case of melanosarcoma of the colon is reported*

8 Two benign conditions of the colon have been described

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while developing is done. If the wet films are found unsatisfactory the same cannula is available and through it another injection may be made immediately or a few hours later.

For interpretation of the films it must be realized that in direct phlebography the contrast medium takes the shortest, easiest route to the heart. It does not perfuse the entire venous system as in the indirect method where the injection is made into an artery. Therefore,



Fig. 157 ~A 31 year old executive had been advised by a specialist in vascular disease that an immediate operation for ligation of the femoral vein was indicated because of phlebothrombosis. He was spared operation because phlebograms demonstrated a patent deep system.

if the internal saphenous vein at the ankle is used, failure to visualize the femoral does not necessarily mean occlusion unless an appropriate block was used to shunt the fluid into the deep system. On the other hand, if the short saphenous is used, the fluid should go directly to the femoral and absence of its shadow is significant. In hypersensitive individuals or when irritating solutions are used allowance for vaso-spasm must be made. Pressure caused by lying on the table can obstruct calf veins.



the first. Another cassette is slipped behind the knee, the patient turned on his side and a lateral view quickly taken. Taking all pictures with the same tube at 2 meters was abandoned, as it did not give as good detail.

We have been unable to use tourniquets successfully. Even with a blood pressure cuff obstructing the saphenous vein without com-

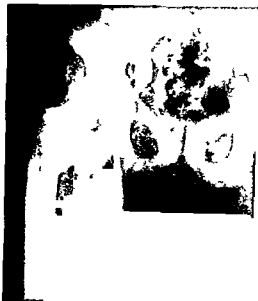


Fig. 156—A 45 year old truck driver was admitted to a surgical service in October 1945 with complaint of pain advancing up the right leg for four days. A tourniquet had kept him in another hospital for the previous 24 hours. The leg was revealed on calf to this

pressing somewhat the deep veins has been too difficult. To shunt the fluid into the deep vein we have used digital pressure on the previously marked site where the saphenous vein crosses the femoral condyle.

When the films have been exposed, saline is washed through the system and the obturator is replaced in the cannula. The patient waits

## PHLEBECTOMY FOR VARICOSIS

DAVID C BULL, M D \* AND ROBERT B HIATT, M D

RADICAL surgery for treatment of varicose veins was generally abandoned in 1890. It was then resurrected from Germany. Five years later it was recognized that the procedure was found to be the rule. Next high ligation with retrograde injection was resorted to with somewhat better results, and then a succession of elaborations of this procedure, calculated to make it more effective. Eventually it became evident that any system of treatment which depended upon thrombosis was ineffective except temporarily and might well make matters worse, as thrombosis damages valves. Following each course of injections, therefore, the leg could be expected to possess fewer functional valves and should suffer more and more venous stasis.

However unsuccessful the early operations may have been, they were gratifyingly free of the complications previously seen caused by thrombosis and embolism. This was credited to the use of local anesthesia and to immediate and frequent ambulation after operation. Flap dissection was unattractive always as it did not permit these two features, and it was abandoned when occasional recurrences were found due to persistence of the trunk. At this stage it was felt that varicosis was caused by incompetent valves in communicators and trunk permitting a column of blood in the latter to exert a constant pressure on the smaller radicals. As edema and ulcers were sometimes seen after all varicosities had been eliminated, it was apparent that the varix was an effect rather than the cause of the disease. It seemed wise then to use the elimination of varices as one index of success rather than as the direct object of the operation. A procedure to remove the trunk and ligate a majority of the communicators was indicated. To accomplish this a 40 year old operation—vein stripping—was revived.

### TECHNIC

Under local anesthesia with 1 per cent novocain the saphenous bulb in the groin is exposed through a 5 cm incision in the inguinal crease (Fig 158 A). Its three or more tributaries are divided between

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Much has been learned from phlebograms. With improved apparatus and technic, especially the rapid film changer, better pictures will be obtained. Meanwhile, phlebography remains the best means of resolving doubts about diagnosis involving the deep veins in the lower extremity and other locations.

ligatures of 5-0 braided silk and the saphenofemoral junction is ligated flush with 3-0 silk. A second snugger ligature of the same material is applied 2 mm distal to the first and the vein is divided distal to it. While gentle traction is exerted on the distal stump, a long fine spinal needle is slid downward along the vein and novocain is in-

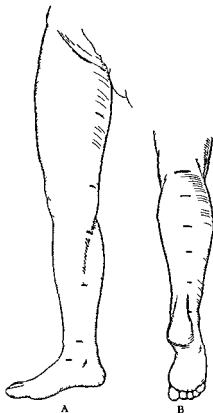


Fig. 160—A Anteromedial view of a patient showing actual location of the tributaries of the long saphenous vein and the incision through which they were ligated. Usually more incisions are needed. B Posterior view showing sites where the tributaries or communicators of the short saphenous were found.

jected as the needle is slowly withdrawn. The stump is threaded through the ring of a Mayo stripper (Fig. 158 B) and the latter is moved proximally until the saphenofemoral junction is felt. The stripper is then removed and novocain is injected into the skin around the incision. The stripper is then moved proximally again, exposing the ring as it shines through the thin

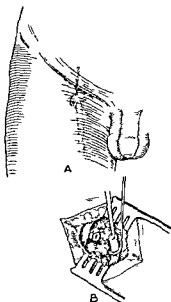


Fig 158—A Saphenous bulb with its tributaries is shown and the conventional groin crease incision to expose them B The saphenofemoral junction has been doubly ligated The vein had been divided and stripper applied

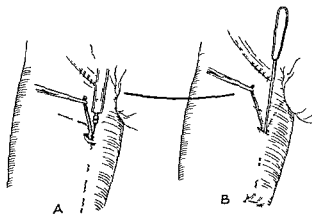


Fig 159—A The vein has been freed down to its first tributary Exposing this

failure to secure every last branch. However, most occur in ulcer cases and are suspected of being caused by excessive standing, as in shaving, on the first postoperative days.

Immediately after the operation varicosities are still present but are smaller and softer. Some thrombose spontaneously a week or two later, but all tend to shrivel up and disappear. A few persist due to leaky communicators at a distance from the trunk. Varices found a year or more later are usually branches of the short saphenous vein when only the long saphenous has been removed or vice versa. For this reason several patients have had a second operation. Persistence of veins due to a leaky communicator at a distance from the trunk should be corrected by ligation of the guilty communicator. Few patients have cared to avail themselves of the second procedure however trivial. In fact, even injections have not been thought necessary to most patients for the small veins persisting after phlebectomy.

### RESULTS

The most important consideration is the result. This has been based on an examination by one or more of the operators two years or more after operation. Many inadequate procedures have been maintained by injections as fair results for a year, but at the end of two years it should be apparent that the result is inferior or that it depends upon injections which of course cannot be continued indefinitely. We are reporting, therefore, no patient who has not been examined twenty four or more months after operation, nor are the letter reports included. All these operations were done during the war, when our Follow up Clinic worked under a number of handicaps including a floating population. An adequate number of cases meeting the minimum requirement of two years will presently be at hand, but at the moment only fifty cases of complete removal of the internal or external saphenous vein, or both, are available. The longest follow up is fifty six months, the shortest, twenty four, and the average, 40.1. In forty three cases the results are classified as excellent, in four more, as good although the patients present some minor cosmetic defect such as a persistent small tributary of the system operated upon or more often tributaries of the other system—usually the short saphenous. They have, however, neither symptoms nor swelling nor any other defect worth further treatment. The results in three cases are rated unsatisfactory because of occasional swelling. No failures have been found yet.

In twenty three cases adequate data are available following incomplete removal of the internal saphenous vein. Only nine results were rated excellent, but seven more were good. Seven were unsatisfactory. Somewhat better results with this procedure were obtained by Mc-

superficial fascia (Fig 159, A) This is split vertically and the vein is pulled up out of the ring as the stripper is withdrawn The branch is divided between 5-0 ligatures The process is then repeated through the second wound (Fig 159, B) and continued downward until the lower border of the medial malleolus is reached Here the vein is ligated distally with 4-0 silk and divided proximal to the ligature, removing the entire trunk intact The fascial edges are reapproximated only in the groin wound and all skin wounds are closed with interrupted 5-0 silk Cotton has been used a few times instead of silk with out noticeable difference

The incisions are made in the skin lines of Langer and the ultimate scars are so inconspicuous that no attempt is made to limit the number (Fig 160) Eight to ten are usually used. Emphasis is placed rather, on ligating every branch to avoid all bleeding Thus post operative discomfort is avoided so that patients do not object to immediate ambulation They walk around the bed every six hours during the first twenty four, then every three hours until the fifth day when they are routinely discharged They are advised to rest for another week before returning to work Those with recently healed ulcers

tary

### COMPLICATIONS

Treatment of varicose veins by the method above described has been practiced 562 times in the Presbyterian Hospital since 1943 when it became routine Partial removal of the saphenous trunk (to upper third of leg) had been done 120 times previously Complications have included no instances of thrombosis or embolism except in the case of our one death

This constitutes an indictment of the staff rather than the pro-  
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Elwee and Maisel who reported 81 per cent satisfactory results with a minimum follow up period of twelve months

The frequency of failure of the current methods of treatment of varicose veins is too well known to the laity to need emphasis to the profession. Homans prophesied many years ago, "Varicose veins and their attendant ulcers . . . may long continue to offer a fruitful field of surgical failure" Freeman in 1939 echoed, "The trail of the varicose veins is laden with chagrin" Experience with total removal of the superficial trunks has shown that consistently good results can be obtained for a follow up period of significant length

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